MILLIONS FROM WASTE

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BY

FREDERICK A. TALBOT

Author of
"The Building of a Great Canadian Railway"—"Inventions and Discoveries"—"The Steamship Conquest of the World"—"The Oil Conquest of the World,"
&c., &c.

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PREFACE

The reclamation and exploitation of waste products for a variety of industrial uses constitute one of the most fascinating and increasingly important developments in modern industry. It is a subject of which very little is known outside privileged circles, and the possibilities of which are but scantily appreciated by the average individual.

The purpose of this volume is to indicate certain of the most obvious channels through which wealth incalculable is being permitted to escape, as well as the narration of something concerning the highly ingenious efforts which are being made to prevent such wastage. While written essentially for the uninitiated reader, the hope is entertained that it may prove of certain service to those who are fully alive to the potentialities of refuse of every description, and who are endeavouring to redeem the country from the charge of being wantonly extravagant in its use and consumption of raw materials, both edible and industrial.

The subject of waste reclamation is too vast and intricate, albeit romantic and fascinating, to be treated within the scope of a single volume. Consequently I have confined myself rather to those phases which are familiar to the average person and to the losses which are incurred from their inadvertent destruction—losses which affect both the individual and the community in general. If it succeeds in acquainting the man-in-the-street and the woman at home with the enormous wastage, both of finance and kind, which are incurred in these most familiar fields during the course of the year, and persuades them to observe methods

of thrift, a material contribution to the national wealth should be effected.

In the preparation of this work I have been extended liberal and courteous assistance from numerous sources. I am especially indebted to the War Office, the National Salvage Council, the Food Production Department, and the Paper Controller, also to several civic and municipal authorities, notably of Glasgow, Edinburgh, Bradford, and San Francisco. I have also been fortunate in securing valuable co-operation from several gentlemen interested in the waste problem, including Messrs. J. H. Pooley and James Macgregor, of Messrs. Ernest Scott & Co., Limited, of London, Glasgow, Fall River, Mass., U.S.A., Montreal, and Buenos Aires; Mr. Jean Schmidt, of Industrial Waste Eliminators, Limited, London; Winget Limited, London; Mr. H. P. Hoyle, of the Grange Iron Company, Limited, Durham; Mr. F. N. Pickett, Hove; and J. Grossmann, Esq., M.A., Ph.D., F.I.C., etc., as well as the Editors of the *World's Work* and *Chambers's Journal*, to all of whom I express my best thanks.

FREDERICK A. TALBOT.

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CHAPTER I

WASTE: ITS RELATION TO COMMERCE AND NATIONAL ECONOMY

EXTRAVAGANCE is the inevitable corollary to cheap living. The expression "living" is used in its very broadest sense, and is by no means confined to the mere consumption of foodstuffs. If living be cheap the thousand and one attributes complementary thereto, from wearing apparel to creature comforts for the home and from raw materials to finished goods, must necessarily rule low in price. Under such conditions the very fact that it is cheaper, as well as easier and simpler, to incur a further capital charge, rather than to endeavour to induce additional service from what is already in hand, though possibly damaged slightly, prompts waste, in precisely the same way as it is more expedient to replace the damaged part of a standardized article, whether it be a motor-car, sewing machine, typewriter, or watch, than to attempt to carry out a repair.

The ready availability of a spare part directly encourages waste more or less. The convenience is provided at an attractive figure to appeal to the consumer, while to the producer it renders a higher proportion of profit than is attainable when it forms part and parcel of the complete finished article. The latter is not marketed at the aggregate of the prices of the integral parts, as one may promptly verify if they feel so disposed. From this it must not be imagined that replacement *per se* is to be condemned, except that it is often attended by the complete loss of the displaced and damaged part. Were the conservation of the removed part conducted the system would be deserving of

whole-hearted support, because in this way the material of which it is wrought would be available for further use. Those firms which insist upon the return of a damaged section before they undertake to forward the replacement are pursuing a wise policy. It is true they consign the faulty or worn part to the junk pile, but, at intervals, the latter is turned over to the manufacturing interests to undergo further exploitation.

It is also somewhat significant to record that improvidence is intimately associated with cheap labour. Cheap living and cheap labour go hand-in-hand. As a matter of fact, until recently the average working members of the community, from the comparative point of view, have been guilty of greater improvidence than those who are well-blessed with this world's goods.

This apparent anomaly is readily explicable. In the houses of the wealthy the accumulation of residues of every description must necessarily attain imposing dimensions. But these wastes are not lost to commerce and industry. In the majority of cases they are handed over to the employees by whom they are regarded as legitimate perquisites. To gratify some individual whim, passing fancy, or from inherent tendency to bargain, these residues are carefully garnered and harboured to be converted into cash through one or other of the many purchasing channels which appear to diverge to these centres. The cooks dispose of bones, fats, and greases, as well as other wastes from the kitchen, to the itinerant rag-and-bone merchant; rejected wearing apparel finds its way to the wardrobe dealer; worn-out copper, iron and aluminium culinary utensils, as well as divers other metallic odds and ends gravitate to the specialists in old iron and waste metals; superfluous produce from the kitchen garden meets with profitable distribution, while even the swill is able to command its market.

It is the opportunity to profit in pocket from such "extras" which acts as the incentive to collect, separate and to bargain for the sale of wastes from a pretentious house. But, as the social scale is descended, the tendency to keep a tight hand upon the refuse suffers unconscious relaxation. This is primarily due to the fact that the volume of such accumulations undergoes attenuation as the social

ladder is descended. As the bulk diminishes so does the impression, "Oh! it is not worth while troubling about!" become accentuated. Finally, when we reach the bottom of the ladder—the average working household—the quantity of waste is considered to be so trifling as to be deemed quite unworthy of consideration. Consequently, here we find the whole, or at least 90 per cent., of the refuse consigned to the fire, or to the rubbish heap, instead of being preserved and turned into a profitable channel to receive a new lease of utility.

As with the home so with the office and factory. The small workshop or business establishment accommodated within one or two rooms records its proportion of waste, but it apparently is so slender as to be comparatively insignificant. Furthermore, as a rule, it is so varied as to aggravate the thought of being more nuisance than it is worth. Accordingly, the refuse is neither sorted nor retained, but, especially if it be combustible, meets with an untimely end. On the other hand, in the large factory, the accumulations being of distinct magnitude, segregation and careful retention are observed to facilitate ready sale, while arrangements are even completed for the periodical clearance of the refuse at mutually satisfactory if not prevailing market prices. Whether the waste ever commands its real intrinsic value is a matter of opinion, because we have never been persuaded to regard the residue disposal problem in the strict commercial sense.

Reflection gives rise to the question—What is waste? A more appropriate explanation than a paraphrase of Palmerston's famous dictum concerning dirt would be difficult to find. Waste is merely raw material in the wrong place. In the spirit fostered by our traditional improvidence we have sought to adapt another existing term to meet the situation. We glibly dismiss waste as rubbish. It is not, but because we have been too indolent to occupy our minds in the elaboration of further possible applications for what we do not actually require for conduct of the operations with which our individual exertions are identified, we seek to satisfy our consciences in the easiest manner. In so doing we essay to flout a fundamental law of Nature—the indestructibility of matter. We have failed to appreciate that what may be of no immediate value to ourselves

may, indeed can, with judicious and scientific handling be persuaded to serve in the capacity of indispensable raw material to other ranges of endeavour. It may even go so far as to supply the wherewithal for the creation of new industries, widening the possible fields of employment, and contribute pronouncedly towards the wealth of the nation.

This fact can be brought home very conclusively. In the opening days of this century the amount of fats, oils, and greases which were allowed to run to waste was colossal. They were cheap commodities and, although they occur in greater or lesser degree with the majority of organic materials in popular request, not a thought was expended upon the possible losses which their discard with so-called wastes represented. But, during the past few years, the demand for these substances has advanced by leaps and bounds. They have become vital to the table in several forms, and this request has brought the food-producing industry into conflict with another trade of far-reaching importance, namely, the manufacture of soap. The situation is rather peculiar, as I point out in a subsequent chapter. Some idea of the volume of fats absorbed in the preparation of magarine and soap, respectively, may be gathered from the narration of the fact that one of the largest soap manufactories in the world demands the supply of fat in a steady stream of about 5,000 tons per week.

A few years ago the activities of this particular firm were concentrated upon the manufacture of soap. It was the solitary product. But it had its attention attracted to the growth and possibilities of the margarine trade, and it decided to enter this market. To-day, its activities are divided between the production of the two commodities, and, curiously enough, almost equally. From its works issue out about 6,000 tons of soap and 4,000 tons of margarine every week.

This merely represents the endeavours of one firm. There are scores of others following a similar line of action. The result is that the demand for fats has reached an unprecedented level. At the moment of writing the coarsest grade of fat is able to command approximately £50—$250—a ton. Is it surprising therefore that every effort should now be made to extract the fats, grease, and oil associated

with every form of organic waste, and that keen effort should be made to secure increasing quantities of waste capable of yielding this material?

So far as the public is concerned this spirited search for fat may be regarded with misgiving, if not absolute alarm. The wizardry of the chemist is acknowledged, and the thought possibly prevails that much of the fat now being turned into margarine is really only fitted for the production of soap. But alarmist or pessimistic feelings in this direction may be speedily allayed, though it is permissible to point out that ten years ago much fat was turned into the cleanser which should have been utilized as a foodstuff, inasmuch as its freshness and wholesomeness were above all criticism. It was merely turned over to the soap-maker because no alternative application was apparent. But conceding the magical qualifications of the chemist, there are some feats which yet remain beyond his powers. The ability to turn bad fat into good for dietetic purposes must be numbered among those achievements which as yet have proved impracticable. If a fat be rancid it cannot possibly be reconditioned for edible purposes. No matter how its preparation may be coaxed and nursed it cannot be converted into a foodstuff. The palate would detect rancidity instantly. Consequently, only the highest grades of animal fat are used for the preparation of margarine; the fact that the big-scale production of a food should have been embraced by the soap-maker merely represents one of those inexplicable coincidences of industry.

It is distinctly interesting, if not actually amusing, to follow what may be described as the utilitarian conjugation of waste. It remains an incubus, if not an unmitigated nuisance, until the chemist, or some other keenly observant individual possessed of a fertile mind, comes along to rake it over and to indulge in experiments. Such efforts are often followed with ill-concealed amusement. A few years since they were even regarded as so much waste of time. In due course some definite conclusion is reached, and the fact becomes driven home that, if such-and-such a process be followed a particular spurned refuse can be utilized as raw material for the production of some specific article. Then scepticism and amusement give way to intense interest and speculative rumination. The new idea is submitted

to the stern test of practical application upon a commercial basis, while the financial end of the proposal, which is the determining factor, is carefully weighed.

These complex issues being satisfactorily settled the exploitation of the erstwhile waste, or rubbish, is energetically pursued. It has now become a potentially valuable by-product, and, accordingly, must be worked for all it is worth. Firmly entrenched upon the market development is vigorously pursued, often to culminate in the quondam waste, now an established by-product, being lifted to such a position of commercial eminence as to dispute premier recognition with the staple in the production of which it is incurred. In more than one instance the by-product has even eclipsed the primary product, or at least attained a level of equal importance, while occasionally the staple has even suffered virtual deposition to rank as little else but a by-product. There are even some cases on record where the manufacture of the staple has been abandoned, at all events for a time, because the by-product, the former incubus of the industry has become invested with such far-reaching importance as to demand the concentration of effort upon its production. Waste—by-product—staple: such constitutes the brief evolution of more than one of the world's leading lines of trading.

Many instances of remarkable topsy-turvydom in this connection might be cited. Possibly one of the most impressive illustrations in this respect, although the transposition is not yet quite complete, is offered by coal-gas. When Clayton first demonstrated the practicability of extracting illuminating gas from coal commercialism feverishly set to work to exploit the gas, and gas only. But the gas proved to be associated with a variety of substances which threatened the very future of Clayton's discovery. Ammonia fumes poisoned the atmosphere of the room in which the gas was burned to the grave danger of the health—even lives—of the occupants according to the cynics, critics, and caricaturists of the day. The tar carried in suspension in the gas was every whit as exasperating because it condensed in the mains to choke them. Ammonia and tar became the bane of life to the gas-engineers of the period, harassing them to the verge of endurance, while the elimination of the two deleterious substances involved the

expenditure of enormous sums of money and prodigious thought.

What is the position to-day. Gas, the staple product from the distillation of coal three-quarters of a century ago, now, to all intents and purposes, is the by-product. The world could roll along very comfortably without it. Indeed, we may have to do so in the near future when the gas is stripped of every other marketable constituent, leaving only a mixture of methane and hydrogen gases to be burned under boilers to raise steam for the generation of electricity in enormous bulk. The ammonia which formerly jeopardized health and lives, and to remove and to throw away which the pioneer engineers strained every nerve, is now trapped to be converted into fertilizer. Then the tar which likewise nearly drove the engineers frantic is now carefully drawn off, collected and resolved into a host of wonderful articles to furnish a diversity of indispensable materials. It would be wearisome to recite the list. It is so lengthy. But it would seem as if the by-products of coal touch every other industry, ranging from dyes to chemicals, flavourings to disinfectants, perfumes to therapeutics and soporifics.

As with coal so with oil. Forty years ago the boring of a well was followed with mixed feelings by the indefatigable driller. A "strike," while devoutly to be desired, was just as likely to bring dreadful disaster swift and sudden, even death, as wealth untold. The driller probed the earth animated by one idea. This was to tap the subterranean lake of crude petroleum. But in driving his bore the driller invariably crashed through the roof of an underground reservoir of petroleum gas. Ignorant of the value of this product, though painfully aware of its danger if allowed to break away and to get beyond control, the early seekers for oil led this gas through a pipe to a point some distance away. There the flow from the open end was ignited and the gas allowed to burn merrily in the open air. The driller knew no peace of mind until the flame flickered and expired as a result of the exhaustion of the subterranean gasometer. Then, and not until, he could resume his boring for the precious liquid with complacency.

But with passing years and progress came enlightenment. The gas is no longer wasted; it is trapped. In some instances it is led through piping for hundreds of

miles to feed hungry furnaces engaged in the making of steel and other products. The earth is even being drilled, not for petroleum, but for its huge supplies of natural gas, and the huge reservoirs thus discovered are being harnessed to the thousand wheels of industry. We even find trains fitted with cylinders carrying natural gas stored under high pressure to furnish light for the convenience of passengers, and to enable dainty meals to be cooked in the kitchens of the dining-cars.

The oil refineries, upon receiving the crude petroleum, set out to recover as much paraffin as they could. This was the primary product, because a brilliant British chemist, Young, had discovered how to distil paraffin from petroleum for lighting, heating, and cooking. It represented a huge advance upon the lamp dependent upon whale oil and the tallow dip. But before the refiners could reach the paraffin they were called upon to wrestle with a lighter spirit which sorely harassed and perplexed them. It was extremely volatile, and highly inflammable—even explosive in the vapour form when mixed with air—and accordingly was construed into a menace to the refinery. It was carefully drawn off and dumped into large pits, where it was burned merely to get rid of it. Its commercial value was set down as nil. A certain quantity was used by laundries and dry-cleaners because of its striking cleansing qualities, but it was used sparingly and cautiously owing to its dangerous character. It could be purchased only with difficulty, and in small quantities by the members of the public, the retailers for the most part being chemists and druggists. If one were glib of tongue and a master of the persuasive art, one might succeed in obtaining as much as half-a-pint in a single purchase.

Suddenly a creative mind evolved the high-speed internal combustion engine, which heralded the coming of the motor-car, the submarine, and more recently the aeroplane and airship. The volatile spirit which hitherto had been spurned and burned wastefully by the refineries was immediately discovered to be invested with a value which had heretofore escaped attention. It formed the ideal fuel for the new motor. Forthwith wanton destruction of the volatile spirit was abandoned. Every drop was carefully collected, and, as time went on and the demand for the light liquid fuel

increased, the refiners put forth greater effort to wring every possible dram of petrol from the crude petroleum. Paraffin, which had hitherto been regarded as the staple, was ignored. It even dropped in commercial estimation as a by-product and became a drug on the market, although, fortunately, the refineries hesitated from repeating the practice they had honoured in regard to petrol—summary destruction by fire.

So insistent and overwhelming has grown the demand for petrol that the producers are hard put to it to keep pace with the requirements. A petroleum boom has reverberated around the world, eclipsing in intensity any stampede identified with the search for gold. To these islands the petroleum age has contributed very little wealth, although it has been responsible for revived interest in the exploitation of our shale—another form of waste—but to Russia, the United States of America, Mexico, and the East, where the earth reeks with petroleum, it has brought wealth untold. It has completely transformed the economic outlook of certain nations, and in some instances has served to rescue a country from bankruptcy To us it is of appreciable significance because, so far, we have been compelled to draw upon distant sources for our requirements and so have to contribute to the national wealth of others, some of whom are our most spirited rivals in trade.

In 1913 our imports of petroleum products aggregated 488,106,963 gallons, valued at £10,856,806—$54,284,030—the contribution from Greater Britain being 22,172,701 gallons, valued at £829,868—$4,149,340. Of this enormous volume 100,858,017 gallons represented petrol for our motors—the waste product of forty years ago at the refineries—for which we had to pay £3,803,397—$19,016,985. In the year when mechanical road propulsion was ushered in petrol could be obtained for about 4d.—8 cents—a gallon: in 1918 it commanded 3s. 6d.—84 cents—a gallon. An increase of over 900 per cent. in value within approximately 35 years represents no mean achievement in commercial expansion, but when it relates to an erstwhile waste product the record is far more sensational.

To relate all the fortunes which have been amassed from the commercialization of what was once rejected and valueless would require a volume. Yet it is a story of

fascinating romance and one difficult to parallel in the whole realm of human activity. It was the waste energy of water which laid the foundations of Lord Armstrong's fortune and the enormous fabric of the huge firm on Tyneside. Sir Hiram Maxim revolutionized warfare by harnessing the wasted kick or recoil to reload and fire his machine-gun, thereby introducing one of the most formidable small arms ever devised to conduct the gentle art of killing. Lord Masham established a new industry and became a millionaire by taking the "chassum" or silk waste—a refuse which had even suffered rejection as a manure because it took such a long time to rot—and utilizing it as a raw material for the production of a new and wonderful range of beautiful fabrics in velvet and plush. It was another textile wizard, Sir Titus Salt, who perfected the process for turning the wool sheared from the back of a member of the camel family roaming the heights of the Andes, and which was classed as sheer rubbish, into the soft glossy fabric known as alpaca.

But one of the most powerful expressions of the possibilities attending the scientific utilization of waste, and one which brings home very forcibly to us the national wealth to be won from refuse, is associated with our woollen industry. Where would Yorkshire be without mungo or shoddy? Dewsbury has become the world's centre for the disposal of old clothes and woollen rags. Here converge all the streams bearing abandoned flotsam and jetsam into the preparation of which wool has entered. There is scarcely anything more disreputable, if not actually repellent, than a sack of woollen rags. But pass that waste through suitable machines and a wonderful transformation in attractiveness, colouring, and design, as well as texture, is accomplished.

Wool can never be worn out. That is an indisputable axiom in woollen circles. It does not matter how man years ago the textile may first have been prepared, nor the many and varied vicissitudes through which it may have passed; it can be used over and over again. It may have travelled through the machines forty or fifty times, may have graced the form of a hundred persons, may have clothed a scarecrow or have been retrieved from a river in the course of its career. True, with each new lease of life it suffers

a certain depreciation, but blended with new wool or cotton it is effectively revived. The history of a fibre of wool would be distinctly romantic and thrilling could it be but written, and even the wildest flights of imagination would be unable to rival stern fact. It is the ability to work and re-work up woollen textile for an indefinite period which has contributed to the prosperity of Yorkshire, and which has enabled this country to build up an export trade in this commodity exceeding £500,000,000—$2,500,000,000—a year in value.

An impressively successful, yet sinister, utilization of waste was brought to light during the war. In their methodical investigation of the dye-stuffs problem the Germans found it necessary to prepare a certain substance which constitutes the starting-point for the production of one of their leading products. Toluol, a by-product from the manufacture of gas, is taken and treated with nitric acid. Now orthonitrotoluol is the specific product in request, but nitrification produces two substances, orthonitrotoluol and paranitrotoluol, respectively. The last-named is of no use whatever, but its production has to be suffered, though, unfortunately, the yield thereof is twice that of the essential article. So far as the industrial pursuit in question is concerned the paranitrotoluol represented a sheer waste.

Now the German, when he encounters a waste, does not throw it away or allow it to remain an incubus. Saturated with the principle that the residue from one process merely represents so much raw material for another line of endeavour, he at once sets to work to attempt to discover some use for a refuse. Manufacturers in other countries were equally troubled with the accumulations of paranitrotoluol because the production of the two substances as a result of nitrifying toluol is strictly in accordance with constitutional chemical law. They also learned that the Germans had succeeded in turning it to advantage. What was this application? This was the poser. They sought enlightenment in this direction but found that the German was resolutely keeping his discovery to himself.

Other countries remained in ignorance until the Germans set out to materialize their fantastic dream of world-wide domination. When their hordes burst upon the frontier

defences of Belgium, and their bombardment played sad havoc with the fortifications of Liege and Namur, the world marvelled. The intense destructive power of the high explosive which was being used was something new to warfare. It was promptly investigated, and then the use for the paranitrotoluol, the apparent incubus of the dye-stuffs-producing factories, was discovered. It was being turned into the destructive agent familiarly known as T.N.T., or trinitrotoluol, to give the explosive its true chemical designation.

It is perfectly obvious, from what has been related, that, if one will only devote sufficient energy and fertility of thought to the study of so-called rubbish and its properties, incalculable economic and financial benefits must redound to the individual. And as with individuals so with nations. The British race is generally assailed as being woefully improvident and remiss in the profitable exploitation of waste, but it errs in excellent company. The United States of America are probably far more guilty in this respect. According to the statement of the American Food Administrator the inhabitants of 24 cities between the Atlantic and Pacific Oceans, by ignoring the latent wealth contained in their garbage barrels, are throwing away sufficient grease and fat during the year to produce 30,000,000 one-pound bars of soap. On the other hand, 300 small towns, by pursuing thrift in this direction, are producing sufficient food from the disposal of their swill to yield 50,000,000 additional pounds of pork worth £1,600,000 ($8,000,000) a year, although in this instance the results might be doubled by the practice of more perfect methods. Another 350 towns, which disdain the value of their swill-tubs, are throwing away approximately £2,000,000 ($10,000,000) a year because they are not inclined to take a little trouble concerning the disposal of their garbage.

Contrast the methods obtaining in the United States and Britain with those peculiar to France. That picturesque figure of French civic life, the *chiffonnier*, is the perennial butt of humorists and cartoonists. But he is a powerful economic factor. Through his efforts millions sterling are saved annually to the French nation. The rag-picker and his colleagues " specializing " in other forms of spoil lurking

in the ash-barrel pursue their work so diligently as to secure everything, except vegetable matter, which is capable of being worked up into other forms by the exercise of brains and commercial enterprise. It may not seem a savoury occupation to rake over the repulsive assorted contents of the household dust-bin, but it serves to swell, to an appreciable degree, the streams of raw materials flowing into the insatiable maws of industry. What is left after these industrious toilers have completed their work finds its way to the dust-destructor to assist in the raising of steam to drive engines and generators for the supply of electricity.

The diligent exploitation of waste exercises a far-reaching influence upon the wealth of nations. If we were to turn the whole of our residues, both industrial and domestic, to the utmost account we should be able to cut down our annual expenditure upon purchases from abroad to a very startling degree. Every ton of import saved not only represents the retention of so much sterling in our pocket, but releases a ton of shipping for the movement of other material, not necessarily to these islands, but between other countries, since it must not be forgotten that we derive an appreciable proportion of our national income from carrying the trade of the world. If we were to salvage all the rags entering into the domestic refuse of the nation we could reduce our imports of wool during the year by 19,000 tons, and allow 15,000 tons of shipping space to be devoted to other purposes. From the yield of cotton refuse derived from the dust-bins we could turn out 16,000 tons of new paper. If we were to become miserly in our collection of waste-paper and to turn it back into the mills, we could secure a further 44,000 tons of new paper during the year and save the import of 75,000 tons of wet pulp from Scandinavia. Were all our old tins handed over to the steel-makers we could reproduce from this raw material 74,000 tons of new steel and dispense with 148,000 tons of Spanish ore. The steel obtainable from the re-smelting of old tins alone would furnish sufficient material to construct approximately forty 3,000-ton vessels.

Fortunately, a change in the national habits of extravagance is to be recorded. The increased cost of living is compelling more sparing use of the necessaries of life and industry. The incontrovertible truth of the axiom "Waste

not; want not," although it may sound rather trite, has been brought home to us. But the complete salvage of waste is probably impossible of realization so long as the kitchen stove and furnace remain. Fire is an excellent destructive agency, but is far too handy for the removal from sight, if not from memory, of the multitude of odds and ends incidental to our complex social and industrial existence. With the coming of the electric age, and the supersession of kitchen stoves and factory furnaces by cheap current, the facilities for the ready destruction of what is really valuable raw material under the guise of waste will be removed. In the interests of economy and wealth, both individual and national, it is to be hoped that the coming of the electric era may not be unduly delayed.

CHAPTER II

THE GERMAN CONQUEST OF WASTE

WASTE creates wealth. If one desire a convincing illustration of the truth of this latter-day precept one has only to cross the North Sea. It is generally conceded that, at the dawn of the second decade of the twentieth century, the Teutonic Empire had the world at its feet so far as commerce is concerned. There is little reason to doubt but that Germany would have become the super-trading nation of the world within a few more years had not territorial ambition and the lust for military conquest have blinded Reason.

The pre-war wealth of the country, that is as it stood in 1914, is universally acknowledged. But what is not so generally appreciated is the circumstance that, to a very marked degree, this wealth was secured as a result of the scientific utilization of waste. In every ramification of industrial and social activity thrift, system, and organization were conspicuous. Circumstances were primarily responsible for the pursuance of such a policy. Germany is essentially an agricultural country. She was dependent upon outside sources of supply for many of the staple raw materials wherewith to keep her mills and factories going. Consequently she was compelled to rely for her existence upon the margin between buying and selling, and she naturally strove to render this difference as pronounced as possible by turning her purchases to the maximum advantage. Even in the exploitation of her natural resources this tendency was manifest, but little wastage being suffered.

The Germans went farther. From the experience amassed in the development of wealth from waste products they were quite prepared to buy residues from foreign competitors, to ship them to the Homeland, and there to

work them up. The country was quite prepared to act as a marine store upon a big scale, because thereby it was able to acquire valuable potential raw materials for infinitesimal expense. The vending countries, as a rule, were quite ready to dispose of their waste at a trifling figure, and often more unfeignedly glad to be rid of what they considered to be a nuisance, comforting themselves with the thought that they had been able to drive good bargains from the sale of what was useless to themselves.

The Teuton buyers were equally satisfied. They generally succeeded in buying useful material at an absurdly low figure. Very often the heaviest item of expense in such transactions was the cost of freighting the waste to Germany, but here they were able to reap distinct advantages from preferential rates. However, such expenditure was speedily recouped because the articles contrived from the erstwhile rubbish commanded a ready sale and at attractive prices. It was by no means uncommon for the Germans to sell the commercial products wrought from the waste back to the very firms whence the last-named had been acquired, and at a considerably enhanced figure.

The strangest feature about these transactions was the keenness with which they were conducted. The countries concerned were far readier to resort to such commercial tactics than to bestir themselves to turn their wastes to similar account, although it must be admitted that the wily Teutons, recognizing the advantage they held, were disposed to invest their processes for translating refuse into commodities with distinct secrecy. They played a gigantic game of bluff and their temerity met with success. If the victims had only reflected they would have realized that such activity was quite possible to themselves; that such enterprise would have provided additional avenues for the employment of their own citizens, and would have contributed materially to their individual commercial wealth.

The Germans ransacked the world for wastes. For instance, who but the Teuton would have gone to stone-fruit packers on the other side of the world and have offered to purchase the stones which the preservers discarded and burned under the factory boilers to assist in raising steam? But the purchasing German firm was astute. The stones were sent home and the packers laughed at

the idea of moving such refuse half-way round the world. The buyers suffered the taunts in silence. Upon reaching the German factories the fruit-stones were cracked and the nuts extracted. These were submitted to treatment to yield a wide range of oils, some of which were turned into essences and liqueurs. Then the Germans dispatched much of this reclaimed produce back to the territory where the stones were purchased, where it was bought with avidity, and at inordinately high prices. Little did the packers think that they were buying back their own refuse in another and useful form and were being compelled to pay heavily for the privilege!

The fibrous residue, remaining after the expression of the oil, was turned into cattle-food, much of which also was sold in foreign markets. The nut-shells were turned into carbon or charcoal, which, from its peculiar quality and high grade, was eminently adapted to laboratory and other uses. We were forced to realize that such shells possess distinct virtues, for did we not encourage one and all to save the stones from fruit to furnish the requisite absorbent material with which to equip the gas-masks served to our soldiers to combat the evils of the poison-gas used in the war! In this connection we were completely forestalled by the enemy. Undoubtedly he was encouraged to launch such a devilish weapon from his discovery of a complete antidote to such aggressive measures in the charcoal made from the spurned nut-shells accruing to the fruit-packing country on the other side of the globe.

Sawdust accumulates in Germany as it does in every country where working in wood is practised extensively. But there the waste is not turned into rivers or burned in destructors as in the United States and Canada. Nor is it dumped in unsightly heaps to rot slowly, used to bed-down stock, or distributed over the floors of butchers' shops and public-houses as in these islands.

A firm conceived the idea of turning this residue to account in the fabrication of a special form of plastic floor-covering. It was mixed with magnesium chloride to form a cement to be applied somewhat after the manner of asphalt, the whole of the area thus being covered and finished off with suitable tools to yield a smooth, level, and attractive finish.

However, it was speedily discovered that this floor-covering suffered from one disability. Magnesium chloride is hygroscopic: it absorbs water, even moisture from the atmosphere, very readily. Consequently it became soft and damp in humid and wet weather. Otherwise it left nothing to be desired, being comfortable to the tread, silent, and warm.

The German is nothing if not thorough. He does not hesitate to harness science to the wheels of industry when the occasion so demands. He realized that to utilize sawdust as a floor-covering it would be necessary to follow strict scientific lines. Accordingly the chemist was called in. He, as a result of prolonged investigations and numerous tests, succeeded in overcoming the outstanding inherent defect of the sawdust paving, and at the same time emphasized that control of the proportions of sawdust and magnesium chloride was essential owing to the first-named varying so widely in its characteristics according to the nature of the wood from which it is derived. Consequently the manufacture of this floor-covering is now supervised by the chemist, and the hygroscopic difficulty has been effectively overcome. The material has achieved a distinct vogue, not only in Germany, but in other countries. It is extremely effective and is relatively inexpensive—the cost averages from 5 to 7 shillings ($1.25 to $1.75) per square yard—bearing in mind its durable and wearing qualities. Incidentally the country has found a highly profitable outlet for its accumulations of sawdust.

The world's consumption of tin-plate has risen to enormous proportions, the extraordinary expansion of the tinned or canned food industry being responsible for this development. Thousands of tons of steel are absorbed in the manufacture of these containers, as well as hundreds of tons of tin and solder. Upon the removal of the contents the tins are generally thrown away, especially by the prodigal nations. This wastage became so flagrant as to arouse the severe condemnation of economists in every country, but these would-be apostles found it well-nigh hopeless to persuade their compatriots to endeavour to exploit the empty tins. Here and there spasmodic efforts were made upon a limited scale to recover the solder, tin, and steel-plate for further use, but the problem did not prove so easy of solution as it had appeared.

The bulk of the vessel constituted a formidable obstacle, while its susceptibility to the ravages of rust was also discovered to be a distinct drawback. In this country the general practice has been to crush the tins flat and to feed them into the blast furnaces as scrap, but in this process the tin vanishes up the chimney, while the solder is also lost, though the steel-plate, which forms 99 per cent. of the composition of the vessel, becomes available as raw material. Nevertheless, although the quantity of tin used is trifling, representing only approximately one per cent., the Germans considered it to be quite worthy of recovery, especially when tin commanded from £150 to £200—$750 to $1,000—per ton.

The Teuton attacked the tin-recovery problem more energetically than his colleagues in other countries and apparently achieved success, although the degree of triumph recorded in this connection has always remained a matter for considerable speculation. Be that as it may the German interests concerned were quite prepared to purchase empty British tins and to ship them across the North Sea to be treated in their home plants. From this fact it is only logical to assume that they had found practical ways and means to consummate the desired end, otherwise they would scarcely have gone to the lengths of organizing a complete collecting system in these islands, and of incurring the freightage charges, although the waste was carried at a low figure. With the outbreak of war, and the rise in the price of tin to approximately £300 ($1,500) a ton, we were forced to inquire into the possibilities of recovering the tin and solder from this refuse, and by energetic action were able to equal, if not to surpass, German effort, so that to-day de-tinning may be said to represent an established British industry.

The fact that Germany was compelled to depend extensively upon outside sources for supplies of raw materials prompted the theory in many quarters that, once the British blockade was firmly established, surrender must follow quickly from economic pressure. But the enemy displayed his ability to hold out for a far longer period than we had anticipated. Why? Simply because the moment he saw himself isolated from his outside sources of supply he inaugurated a more rigid system for the compulsory collection,

segregation and utilization of his domestic waste. We know to-day how sternly these orders were enforced, and how completely the country was covered by official organizations established to this end.

To ensure that nothing of industrial value should be lost a collecting centre was established in every village and hamlet, the local chief magistrate being vested with wide powers for the conduct of the work placed in his charge. It was his duty to see that everything and anything capable of further exploitation was retrieved. The inhabitants were notified by public placard that they must bring and surrender their accumulations of refuse to the collecting centre at specific intervals, according to the available machinery and the population of the village. The head of every family or household was held personally responsible for the preservation of anything capable of further use and residue incurred within his home. Any dereliction in this respect, or infraction of the official commands, was subject to punishment according to the nature of the offence.

The materials which were in greatest demand were duly set forth. They included such junk as old metal of every description, from useless cooking utensils to fragments of wire, worn-out tools, abandoned implements and nails recovered from packing cases: textile odds and ends no matter how old and threadbare from the heterogeneous contents of the rag-bag to discarded suits, dresses, hosiery, frills, ribbon, and hats: and kitchen waste in infinite variety. The metal was turned over to the munition plants, the textile waste to the woollen, paper, and other mills, while the organic waste was distributed throughout the countryside for feeding stock after the fats and greases had been extracted.

In the towns and cities similar organizations were created, only in these instances the regulations were somewhat more stringent. All and every kind of kitchen waste had to be surrendered daily. In the leading cities it was incumbent upon every householder to have his accumulation of refuse from the previous day ready for the arrival of the official collecting cart. As this passed through the street in which he resided he had to carry and discharge his consignment of refuse into the vehicle. In some in-

stances, as in Berlin, this task involved early rising because the collecting duty had to be completed before 7 a.m.

In the towns and cities the waste was most rigorously controlled. It was criminal for the housewife or maid to permit the grease clinging to the plates and dishes from the table to escape down the sink. This fat had to be emptied into a special pail, and with the minimum of water. Terse instructions as to how this could be done to the satisfaction of the authorities were issued. It would seem as if the salvage of grease were carried to an absurdly fine degree, but in view of the prevailing circumstances the authorities were justified in compelling the recovery of such an apparently insignificant trifle as a dab or two of grease upon a dinner-plate, since it was found that the daily yield of fat from the average town was about 8,000 pounds. Truly the enemy may be said to have fully realized the truth that "many a mickle makes a muckle."

But the inhabitants, though forced to gather all their fat with such scrupulous care and to surrender it to the authorities, were enabled to receive a certain proportion back again—by paying for it—in the form of soap. The fat was secured in order to extract its glycerine content for the production of explosives, a certain quantity being set on one side to be turned into a lubricating grease to keep the oil-starved mammoth machine plants of the country going. The residue remaining after the extraction of the glycerine was turned into soap.

Skins, rags, bones, feathers, hair, rubber-scrap and other articles too numerous to specify were collected by this machinery. All waste arising in the slaughter of animals for food was carefully gathered. Special factories were reserved for treating the carcases of animals which had succumbed from old age, accident, disease and other causes. A farmer was not even permitted to bury the corpse of a dog. The authorities alone were vested with the power to handle deceased animals. These were thrown into suitably designed vessels, sufficiently large in some instances to receive a horse intact, which were then hermetically sealed to prevent the escape of noisome gases. Cooking was pursued to secure the fats and other products arising from the destructive distillation of the dead animal. The

gases which were thrown off during the process were carefully collected, condensed to shed any foreign particles which happened to be in suspension, and then fed to the furnaces to assist in raising the heat required for cooking. By the time the distillation process had been completed only a minute quantity of fibrous residue remained together with the solid particles of bones. This mass was ground up and converted into chemical manure.

The shortage of oil was most keenly felt because this affected every range of the industrial and domestic life. Perhaps we do not generally realize the fact that all machinery would be condemned to immobility were lubricating oil supplies to be cut off. But it was not only imperative to keep the war material factories, trains, trams, motor vehicles, electric generating stations and a host of other plants in operation. Fats were in demand for a more vital issue—the table. To meet the shortage of butter, vegetable or nut-oil and animal margarine, fats and greases were in urgent request.

To mitigate the deficiency in this direction as far as possible a further rigorous enactment was put into force. It was rendered a penal offence to throw away the kernels of plums, peaches, apricots, prunes, cherries and other stone fruits or even the pips of apples and pears. One and all had to be carefully husbanded and surrendered to the authorities at special collecting stations, which, for the most part, were established in schools and municipal buildings. Juvenile effort and enthusiasm were fired. The school children were urged to maintain an alert eye for such raw material and were also encouraged to gather acorns, horse-chestnuts, and beech-nuts. The yield of such residues must have been enormous in the aggregate. One city alone reported the production of over 300,000 pounds of oil during a single year from the various nuts collected within its jurisdiction.

In the exploitation of gaseous products the Germans have undoubtedly displayed remarkable initiative. They certainly pioneered the use of the gases arising from the manufacture of pig-iron. It was the practice to allow the gases from the blast-furnaces to escape into the atmosphere. Seeing that approximately 150,000 cubic feet of gas arise from the production of a ton of pig-iron, and bearing in mind the output of the ironworks, it will be seen that the

wastage in this direction must have represented a formidable item during the twenty-four hours.

These waste gases were chemically investigated, and it was discovered that approximately one-fifth of the total volume thrown off consisted of carbon monoxide gas which has a very high heating value. Thereupon the Germans set to work to recover this gas, to clean it and to convert it into a fuel for driving suitably designed gas engines. Years of labour and study were devoted to the problem, which was discovered to be exceedingly abstruse. But the obstacles were overcome and the blast-furnace gas engine made its appearance. The perfection of this means of utilizing a waste product has revolutionized a certain phase of industry throughout the world. One of the first firms to adopt the new idea was the Krupp establishment, where the gas collected from eight blast-furnaces which hitherto had been allowed to escape into and mingle with the atmosphere was harnessed to drive fifteen big engines. The perfection of this achievement in waste utilization speedily became reflected throughout the country and was subsequently introduced into this country where vast strides in connection with its use have been made.

Much has been related concerning the development of the airship in Germany, but this has been due in no small measure to the fact that it afforded a profitable outlet for the utilization of a waste product—one absolutely vital to the airship. I refer to hydrogen. This gas is produced in enormous quantities at many German works, and, for a considerable period, had to be ignored because no industrial use for it was apparent. A certain quantity was absorbed in the synthetic production of precious stones—topaz, rubies, and sapphires—but this consumption was trifling. Its fellow, oxygen, remained a drug on the market for many years until the coming of the oxy-acetylene and oxy-hydrogen method of welding and cutting metals came into popular favour. Then the demand for oxygen expanded so rapidly as to compel the laying down of plants for the production of oxygen from water by electrolysis. But the increased output of oxygen released still larger quantities of hydrogen for which practically no market obtained.

Consequently the endeavours of Zeppelin and his contemporaries received every encouragement. With the

conquest of the air by the dirigible all anxiety concerning the profitable use of hydrogen disappeared. At one large factory, producing this gas in huge volumes, a special plant capable of filling the largest Zeppelin craft was laid down. The low figure at which hydrogen was obtainable was responsible in no small measure for the popularity of ballooning in Germany in days previous to the coming of the airship. The use of coal-gas for this purpose was discouraged: it was far more valuable for fuel applications, whereas the hydrogen was not only a superior lifting agent but deserved employment because it offered a remunerative outlet for a waste, and would assist in the expansion of other industries depending upon supplies of cheap oxygen.

To encourage the aeronautical use of hydrogen the firm in question embarked upon another branch of trading. It assumed the manufacture of cylinders or steel bottles for the storage of the gas under pressure—up to 200 atmospheres. Batteries of these bottles were maintained in a charged condition ready for instant dispatch to any part of the country in reply to a telegraphic or telephonic order. The airship pioneers in Germany were never in a quandary concerning the acquisition of the indispensable gas, nor were they faced with the obligation to lay down their own plants for its supply to meet their individual needs. Hydrogen was obtainable in any desired quantity at the end of a wire, and could be purchased as readily as a truck-load of coal from a colliery, while it was also available at an attractive price.

To deal fully with the German conquest of waste would prove wearisome. Enterprise and initiative are apparent in every direction from the use of recovered solder for the production of toy soldiers to the wholesale stripping of motor-cars and cheap clocks for their integral parts. Little wonder therefore that the Germans built up a wealthy national fabric. But probably the most striking evidence of the truth of the assertion that waste creates wealth is extended by the coal dye-stuffs industry. Sixty years ago the tar arising from the distillation of coal was as anathema to the engineers concerned, as I have previously related. Its disposal offered a pretty problem. It was difficult to burn, could not be turned into streams or the drains, and could not be allowed to dissipate itself into the ground.

Any one who was prepared to fetch it could take it away with the engineer's most profound blessings. It was waste in its most compelling form.

Then came Perkin with his discovery of mauve from the much-maligned tar. Immediately the former anathema of the gas-works became invested with a new and indefinable significance. But so far as Britain was concerned little progress was to be recorded. Perkin struggled valiantly to establish a new industry in this country, only to suffer discouragement and ham-stringing obstruction for his ingenuity and enterprise. The Germans appropriated the discovery and prosecuted researches and experiments so vigorously and whole-heartedly as to build up one of the biggest monopolies known to industrial effort.

It was not until the declaration of war that the world recognized the extent of the tribute it had been prepared to pay annually to the Teuton in this one field of trading. The sudden interruption of supplies of colouring agents derived from coal-tar, and made in the huge factories fringing the Rhine, Main and Spree, threatened a whole host of trades from China to Peru. The competitive nations were forced to turn their attention to the mastery of an industry which hitherto they had virtually neglected in order to keep their industries alive, only to discover that they had much to learn. In the United States thousands suffered want and distress from unemployment just because the stocks of dyes had run out and their domestic dye-manufacturing plants were unable to rise to the occasion with sufficient promptitude. Antiseptics were difficult to procure, especially those which had achieved such a wide measure of popular favour during recent years, because they were of German origin and were no longer forthcoming. Amateur photographers were compelled to pack away their cameras and to forgo the pursuance of their hobby until such time as the essential chemicals once more became procurable and cheaper, while doctors were forced to polish up long-forgotten or rusty knowledge concerning the herbaceous drugs which had been displaced by those derived from coal-tar.

A few figures will serve to drive home the stranglehold which the Germans had secured upon the trade of the world from the scientific exploitation of a waste product. For

5,000 years India supplied the world with indigo which was of vegetable origin. Apparently it held an unassailable commercial position and was held in particularly high esteem by Japan and China. Bauer, the German chemist, resolved to solve the indigo riddle and at once set out to make it from coal-tar. It proved a difficult quest occupying many years and involving thousands of experiments. But perseverance brought its due reward although success was not recorded until a round £1,000,000 had been spent. Then, before it had become established upon the market, it suffered eclipse by an improved process which had also been perfected by a German.

Within five years of its appearance upon the market synthetic indigo had driven its natural rival from India virtually into oblivion. The coal-tar competitor even established a firm foothold in the land where the vegetable article had held sway for so many thousand years. Throughout China and Japan a similar story was related. Indian indigo was no longer required. It was beaten hopelessly in price, the factor which counts in commercial circles, by the synthetic German article. Of the artificial colouring materials imported by China German indigo claimed two-thirds. A seventh of the artificial dyes imported by Japan was German indigo, while one-tenth of the dye-stuffs imported from Germany into the United States was artificial indigo.

As a result of less than fifty years' ceaseless endeavour Germany built up an industry specializing in the manufacture of tinctorial matters derived from coal-tar, capitalized at £50,000,000—$250,000,000—and had a list of 2,000 different colours of a synthetic character which she could supply, one thousand of which were in steady daily demand. We talk about the restoration of the British coal-tar dye-stuffs industry. The Americans voice a similar story. It is glib. How far have we got? As a result of five years' hard work in Britain we are in the position to market about 300 of the 2,000 dye-stuffs which Germany has in her trade catalogue, while America can point to a list of about 200. True, these represent many of the colours which are in heaviest request, but it will be seen that we have a very long way to go yet before we can claim to have wrested the industry from Germany, while in comparison with the £50,000,000—$250,000,000—of capital invested in the

Teuton industry, the £5,000,000—$25,000,000—sunk in the British enterprise appears paltry.

To indicate how industriously and comprehensively the German houses have probed this particular waste utilization problem it may be mentioned that one of the leading houses in the industry has taken out approximately 6,500 patents to protect its activities, while it turns out a round 2,000 different products all made from coal-tar. The manufacture of the synthetic drugs—aspirin, veronal, sulphonal, phenacetin—and a host of others runs into stupendous figures. That concerning antiseptic preparations as well as the production of chemicals incidental to photography and the leather trades is equally imposing. It is estimated that the total capital sunk in German enterprises identified with the exploitation of coal-tar ranges between £140,000,000 and £160,000,000—$700,000,000 to $800,000,000. The return is exceedingly attractive, exceeding £80,000,000—$400,000,000—per annum in value.

To the British nation the magnitude and prosperity of this huge traffic in coal-tar derivatives with its enormous wealth is particularly galling. Had we displayed a more sympathetic attitude towards the discovery of Perkin and his endeavours, and had we displayed similar initiative, energy and enterprise the monopoly which became Germany's might have been ours. But we disdained to exploit a waste. We left it to a persevering rival, and became content to pay him tribute for the utilization of a fundamental British discovery and incidentally to charge his coffers with the sinews of war. Had we kept the potential treasure-house of coal-tar to ourselves the history of the world might have been written very differently. It was the wealth accruing from the coal-tar dye-stuffs industry which enabled Germany to play a far bigger part than may be generally conceived in the development of her other industries, especially that pertaining to the chemical trade, the dye-works constituting the nursery where Germany raised her battalions of chemists.

It must not be inferred from what I have narrated that the German has a peculiar prerogative in the mastery of waste products: far from it. In certain ranges of industry we have eclipsed the Teuton and have paddled our own canoe so far as blazing the trail of industrial economy is concerned. Nor is the Teuton temperamentally better

adapted to the scientific exploitation of refuse. For the most part he has been compelled to investigate these divers potential raw materials to maintain his industrial existence. Moreover, as may be readily conceived from what I have related, the issue has been forced upon him by repressive official machinery and legislative measures. Discipline in this as in many other fields has fulfilled its purpose. Certainly it has reduced every German scrap-heap and dump into a Tom Tiddler's ground and the application of its contents into a semi-automatic operation, or at least into part of the intricate routine of industry. It is to be hoped that we have not allowed the lesson thus taught to be lost. By now we should have learned, and digested thoroughly, the truth of the precept that waste creates wealth—and commercial power

CHAPTER III

SALVAGE FROM THE ARMY SWILL-TUB

WASTE is one of the concomitant evils of a high civilization. Undoubtedly it is incidental to the primitive as well, but to a lesser degree. In this instance, however, the waste incurred does not represent a complete loss, because upon being discarded it decomposes, and thus continues the cycle of Nature.

Under conditions of advanced civilization, where a blind worship of Hygiene rules, residues of an organic character, from their very ready susceptibility to decomposition, are construed into a menace of health, although, as a matter of fact, the danger in this connection is more imaginary than real. Such refuse invariably suffers destruction by fire or by some other so-called sanitary method involving either the total or almost complete loss of valuable materials. We satisfy our consciences, however, by reflecting that the pursuance of such drastic methods satisfies the faith of hygiene, although the community suffers very pronouncedly in pocket in the long run.

It is only when pressure becomes exerted by some stupendous cataclysm, such as war, bringing in its train the peril of a bare sufficiency of foodstuffs, which in turn provokes high prices, that it becomes possible to combat the ignorance born of erroneous enlightenment in regard to matters hygienic. Under such conditions the gospel of retrenchment and reform may be preached with greater promise of accomplishing success. But the community, considered as a whole, even in time of adversity, is slow to depart from accepted practice. Precious time is lost in the application of the precept of making one pound go as far as did two pounds under more congenial conditions.

It is a matter for extreme satisfaction, if not one of aggreeable surprise, to learn that, so far as Britain is concerned, it was the army which blazed the trail of economy, particularly in regard to foodstuffs. This certainly sounds amazing, because the Military Service has ever been regarded as the national sink both for finance and kind. Nevertheless, no matter how guilty of squandering it may have been during the opening months of the war, the sins of omission were subsequently rectified, to present a striking object-lesson to the civilian section of the community in regard to the scientific utilization of what the soldier was unable to consume, and its ultimate presentation to commerce in a variety of forms for the manufacture of other products of an indispensable character, or foodstuffs. By the practice of rigid economy along these lines, and without pinching or squeezing the food allowances to the soldier in the slightest degree, millions sterling a year were, and still are being, saved to the tax-payer.

When signs of coming food stringency for the civilian element of the nation became manifest, as a result of the relentless submarine campaign inaugurated by the Germans, combined with the necessity to concentrate shipping upon forwarding supplies to the fighting forces, the moment was considered to be propitious for putting into operation a scheme of retrenchment and reform. It had already been prepared, and was merely awaiting application. The only question demanding care was the introduction of the proposal in such a manner as not to impair the soldier's physique and health.

During the opening days of the war, when the authorities were faced with the absorbing problem of enrolling men, food wastage assumed enormous proportions. Severe criticisms were levelled against the military authorities, and doubtless the strictures were more or less deserved. But extravagance under the conditions which prevailed was inevitable. By a stroke of the pen the effective strength of the British Army was increased from 180,000 to over a million men. Lord Kitchener's call proved so irresistible as to persuade men to enlist in far more imposing masses than had ever been anticipated. The ranks were swelled by recruits from all stations of life, and their tastes were as diverse as were the positions they had previously held

in the complex social scale. The transition from civilian to military life was too sudden. The men naturally clamoured for subsistence more or less in consonance with what they had been for so long accustomed in private life. If the food did not coincide with their fancies it was promptly thrown away.

The difficulty of the situation was further aggravated from the circumstance that many men who were promoted to commissioned rank were generally deficient of all knowledge pertaining to the commissariat. Consequently it is not surprising to find that the elaboration of an economic reform from the victualling chaos which prevailed proved a stupendous task.

In pre-war days the disposal of the waste from the soldier's table constituted a relatively simple task. All residue went into what is known as the "swill-tub." This convenient receptacle did not completely represent the military equivalent of its civilian counterpart, nor were the contents on a level with the combined solid and liquid odds and ends of an organic nature from the table of the ordinary individual. The military swill-tub was regarded rather as a handy vessel for the receipt of anything and everything which was no longer required, or which did not present any further apparent use to the soldier.

The system of disposal was likewise adapted to the prevailing circumstances. The 180,000 troops forming the standing army at home were distributed throughout the length and breadth of the United Kingdom, and thus became resolved into scattered military colonies, not one of which was of pronounced numerical strength. Consequently a centralized scheme for dealing with the waste could scarcely be introduced with any likelihood of proving profitable or successful in working. Local circumstances governed the issue very materially. The disposal of the garbage was vested in the local commanding officer, while the proceeds from the sale of the swill to farmers and others went into the regimental funds.

Notwithstanding this ostensibly haphazard arrangement it must not be supposed that the farmer was able to secure the spoil from the local garrison for a ridiculous figure. The erstwhile army officer has often been assailed for his apparent lack of business acumen, but, in so far as the

disposal of this swill was concerned, he often proved a hard bargainer as many farmers and swill-buyers will readily concede. The higher the figure the officer was able to realize over the transaction the more enhanced was the sum with which he could swell the regimental coffers. It was only in those instances where disposal was attended with difficulty, or where accumulation of the garbage would have constituted a distinct menace to the health of the troops, that low prices obtained.

This method had to hold sway during the initial rush to the colours. But the moment the opportunity opened for an attack upon this problem as a whole it was accepted. A new inspection department was created by the Quarter-Master-General which became known as the Quarter-Master-General's Services, accompanied by the appointment of a chief inspector who was charged with the control of the whole question of messing and the profitable exploitation of the residues accruing from the feeding of the troops. This department appointed competent inspectors to conduct the work in hand to a successful issue, while the catering issue became centralized under an Inspector of Army Catering.

The combined scheme of centralization and decentralization brought the Chief Inspector into intimate touch with the problem in all its varied phases, and the messing of the army as a whole was now placed upon a solid foundation. The inspectors attached to the Home Commands distributed throughout the United Kingdom drew up exhaustive reports upon the issue as it affected their respective centres. From the subsequent digestion of these reports it was found possible to adjust the supply of food to the soldier's actual requirements and to effect the first reduction in his rations.

The original issue comprised 1 lb. of bread and ¾ lb. of meat per man per day, because, in accordance with the long-established peace-time procedure of the army, which was continued after the outbreak of war, the national upkeep of the fighting man involved the supply of only these two staples. Whatever else the soldier fancied he had to purchase for himself, in which direction he was assisted by his messing allowance of 7½d. (15 cents) per day. When the matter was investigated it was learned that this issue was in excess of the average man's actual needs. Never-

theless the full ration of meat was generally cooked, the soldier consuming as much as he desired, while what he left over was relegated to the swill-tub. It was the same with the bread, the residue likewise being discarded to this convenient receptacle. Consequently the first move was to adapt the rations to the soldier's consuming powers.

It was also discovered that considerable waste arose from the indifferent manner in which the meat was prepared and cooked. The tastes of the men, especially of the recruits to the New Armies, varied very widely according to the social scales from which they had been drawn. But while the men from the higher ranks of life were not fastidious they did at least demand the skilful and appetizing presentation of their food. If the meat were indifferently cooked it was simply left untouched to find its way to the swill-tub.

Accordingly, it was decided to improve the military cuisine forthwith. The kitchen service was severely overhauled, only the most competent and expert cooks being retained in this service. In pre-war days the army maintained only one Cookery School—at Aldershot—from which all military cooks graduated. But as the armies grew in millions this solitary university proved hopelessly inadequate. Accordingly, cookery schools were established in each command while a totally new curriculum was introduced.

The cookery school became the "key" to the whole situation. It not only became the nursery where the autocrats of the field-kitchen were raised, but it was the hive in which many little wrinkles were learned, where new ideas were submitted to initial test and practice, to be adopted throughout the armies if they established their value, and where economies were subjected to exacting trial for widespread application upon issuing unscathed from the ordeals to which they were imposed. The improvement in the personnel, training, and methods of the men in charge of the field hotels proved successful in another direction. Higher efficiency and contentment among the troops were recorded, for the simple reason that a satisfied, well-fed soldier provides the finest fighting material.

With improvements in cookery the contents of the swill-tub commenced to dwindle in volume. Less food was wasted while the residue from the table similarly de-

creased. As this development was pursued it was ultimately found possible to reduce the rations of bread and meat still further without provoking the slightest discontent. A third reduction in the rations took place in 1917 to the extent of an additional two ounces of bread, except in the case of soldiers under nineteen years of age, and a quarter of an ounce of salt per man per day. The cumulative results of these economies represented a direct saving annual of £4,000,000—$20,000,000—in cash to the nation in respect of the soldiers' rations. In other words, the huge armies of 1918 consumed less food to the value of four millions sterling than was the case two years previously, and this satisfactory end was achieved without stinting a man. Such a remarkable result was primarily due to the improved method of preparing and serving the food. During the war more than 50,000 men were passed through the cookery schools attached to the Home Commands. The effect of such imposing economies proved of distinct benefit to the community, because the reduced supplies to the Army released so much more bread and meat to the non-combatant element of the country.

The serving of meals, at least so far as the Home units were concerned, was also completely transformed. Instead of the men being compelled to indulge in a wild scramble with their messing-tins for their meat supplies, the latter was cut up in the cook-house and assigned to dishes for the table. Each man thus became assured of his allotted ration. But in the event of the allocation exceeding what the soldier desired, as for instance when he was a trifle off his feed, instead of being compelled to take his ration willy-nilly, eating as much as he fancied and leaving the balance on his plate to swell the swill-tub, he was instructed not to help himself to more than he felt he could attack. If, after settling down to his meal, he found his appetite to return unexpectedly, he was free, after the manner of Oliver Twist, to ask for more, with this difference—he was sure to receive it.

Although under this *régime* the cooks were given less raw material with which to carry out their appointed tasks, yet it was found possible to induce the lesser quantity to go farther than the larger allotment had ever gone before. Other economies resulting from the observance of more scientific culinary methods were also recorded. The intro-

duction of women into the kitchen was tried. This experiment, doubtless owing to the fact that this represented a woman's true sphere and from her inherent tendency to be careful, efficient, and thorough in every detail concerning the preparation of meals, proved a conspicuous success.

Now, no matter how persistently and effectively the lessons of economy may be preached in the kitchen and at the table as much in the home as in the army, and notwithstanding the infinitesimal degree to which the proportion of spoiled food may be reduced by the introduction of superior methods and skill, a certain amount of waste is unavoidable. It cannot be overcome in its entirety. Tastes differ so widely that odds and ends are certain to be left untouched upon the plate, while a certain accumulation of gristle, bone, fat and other inedible portions must be expected.

The residue upon the individual plate may be so insignificant as to render a second thought concerning its probable value superfluous. But, multiply that individual plate and its contribution of waste by the tens of thousands of plates in use at one time, as in the army, and it will be realized that, in the aggregate, the fragments assume a very imposing volume. Furthermore, in the kitchen where the joints are cut up, the accumulation of pieces is striking. Lastly, in washing up the plates, dishes and other utensils what an avenue is offered for the escape of immense quantities of fat through the sink gully? I have already indicated in a previous chapter what wealth may be lost in this manner, and how it only needs adequate reclamation methods to enable such loss to be avoided.

Accordingly, contemporaneously with the reorganization of the catering and cooking issues, the exploitation of the now appreciably attenuated swill-tub contents was investigated. This residue was still being sold to the farmers, but they were not regarding their purchases with unalloyed delight. Contrary to general opinion, perhaps, raw swill does not constitute an ideal foodstuff for porkers. As a rule it is too rich in fat and so tends to exercise a debilitating and impoverishing effect upon the animals, being a frequent cause of scour.

About this time a grave problem asserted itself in another field of military activity. The Ministry of Munitions had

decided to speed-up the output of explosives, but such acceleration was threatened by a shortage of the indispensable constituent, glycerine. It was not a question of the facilities for the production of this essential being insufficient to cope with the demand because ample plant was available. The difficulty was the dearth of animal fat which yields the basic material in question. Soap manufacturers were also being hard-pressed for similar fats to conduct their operations. As a result of the depressing outlook the price of glycerine commenced to advance upon the market at a disconcerting rate.

The military authorities, cognizant of the huge quantities of animal fat reclaimable from the swill-tubs throughout the service, recognized the opportunity to ease the crisis to an appreciable degree. The segregation, collection, and surrender of this potential raw material to the industry concerned were merely matters of organization. It was promptly realized that if the issue were left for adjustment to the interests generally identified with such enterprises, and in which the itinerant rag-and-bone merchant and marine store dealer figure prominently, confusion would ensue, conducing to further disturbance of prices.

To achieve the desired efficiency the authorities invited the trade, comprising the soap-makers and the bone degreasers, to discuss the question. The authorities succintly narrated what they could do towards the solution of the problem. The trade was agreeably surprised by the facts and figures which were set before them, and was quick to appreciate that here indeed was a new and unexpectedly rich mine of raw material to be advantageously tapped. The Ministry of Munitions, also represented at the conference, announced its preparedness to extend a willing hand. It would take over all the glycerine derived from fats procured from military sources at a fixed price. This was mutually settled at £59 10s.—$297.50—per ton, and it was agreed that the figure should remain relatively firm irrespective of market fluctuations. It must be conceded that the Ministry drove an astute bargain, because at the time glycerine was commanding £300—$1,500—per ton upon the open market, which sum the country would have been compelled to pay had the military sources of supply not been available.

The trade acquiesced and formed a committee including officers nominated by the War Office to complete all negotiations and transactions. Private buyers were nominated to cover the whole country and a flat rate for the purchase of all fats from military sources was decided. By this simple arrangement every unit throughout these islands, no matter how remote its situation, was assured of a definite market for its fats and bones. Moreover, these units were given strict instructions to sell their produce only to the trade representative at the price decided, notwithstanding that other would-be buyers might proffer a higher quotation.

So far as the army was concerned the remunerative market for all waste in the form of fats and bones being established, it now became necessary to whip up the contributions of these residues to the uttermost ounce. A whirl-wind campaign was conducted throughout the whole of the Home Commands to demonstrate how this end might be consummated. Officers of the department concerned visited the various camps. It was calmly but firmly impressed upon the local responsible officers that they must resort to every artifice to trap fats and bones during their devious journeys, so that nothing might escape. There were heart-to-heart chats with the cooks, who, their imagination fired and enthusiasm kindled, promised to leave no stone unturned to satisfy the authorities in this direction.

Only one danger was to be apprehended as a result of this campaign of enlightenment. In their zest to save the fat the autocrats of the kitchens and others might unconsciously deprive the soldier of his proportion of this food so essential to the maintenance of a high standard of health. Accordingly, while one and all were urged to keep a tight grip upon the waste, they were instructed to allow the fighting man to eat just as much fat as he fancied: indeed his consumption of the highly nutritive dripping was to be specifically encouraged because, in this manner, it would become possible to release increased quantities of butter and margarine to the civil population. Holding the scales evenly between the soldier and the cook-house on the one hand, and between the troops and the civilians on the other, proved to be one of the most intricate and delicate problems associated with this waste-saving campaign.

To secure the fullest co-operation of the cooks the Army

Council agreed to the extension of a specially attractive inducement. An extra daily financial allowance was sanctioned on the basis of the more fat the cooks saved and turned over to the making of munitions the better they would be off in pocket. This allocation, however, was not to become a charge upon the public purse. It was insisted that it should be defrayed from the sum realized by a unit in the disposal of its waste fats and bones, while the balance was to be devoted wholly to the provision of kitchen utensils and other amenities. The units alone were to benefit from the practise of economy and obviation of all waste.

The consummation of this arrangement led to one or two amusing sequels which, it is to be feared, had scarcely been anticipated. Naturally every camp became uncannily keen to derive the utmost profit from this phase of permissible trading, and a certain rivalry developed between the various units to score top marks.

There was one camp, composed of men drawn from units scattered all over the country, undergoing musketry training. The men became affected with the "save your bones" craze to an acute degree. As a result of his periodical investigation the commanding officer suddenly discovered that he was getting all the fat he wanted. But the bones! That was a different story: the yield was by no means what it should have been. The startling discrepancy prompted inquiry, and the officer found that the soldiers were more fully alive to the real significance of the swill-tub than he had imagined. But they were more loyal to their own units than to the musketry camp to which their attachment was only temporary. They were waging a quiet campaign among themselves, collecting all the bones upon which they could place their hands, and determined that their colleagues should derive all the benefits accruing from the sale of this waste were posting their bone-hauls back to their own units!

Another instance of similar zeal was even more humorous. A certain Imperial unit was camped next door to some troops from Overseas. The "save-your-fat-and-bones" scheme was carefully explained to the latter, but having come from a land where meat was plentiful they failed to see the object of being so vigilant and miserly in regard to the residue in question. The authorities, realizing the situation, refrained

from further pursuit of their proposal, being content to allow what they had already expressed to sink into the minds of the soldiers, confident that, upon reflection, the Overseas unit would appreciate the wisdom of the official recommendation.

The expected happened. The men from Yonder Britain in the end did conclude that there was something in this waste-saving stunt, and that they might profit from following the general practice. They commenced to indulge in bone-collecting and hoarding with rare gusto. No schoolboy ever collected postage-stamps more keenly than did those fighting men from Farther Britain save bones and fat.

This outburst of zealous economy delighted the authorities. They saw the yields from the camp of the Overseas fighting men rising by leaps and bounds. But there was a decrease in the bone-yield from the Home unit next door! The supply officer, feeling that something must be amiss, and that possibly the Overseas troops were receiving an inordinate quantity of bone in the issue to stimulate collecting, dived into the mystery. It did not prove to be a very baffling quest. The Overseas unit was able to show a high yield of bones because it was indulging in surreptitious nocturnal raids, at opportune moments, upon the bone-stocks of its neighbours!

As the scheme was brought into wider and wider application it was found that the exploitation of the actual swill-tub might be conducted to still greater advantage. Hitherto the task had been the redemption of the bones and waste fat before it reached the actual garbage barrel. But to turn the actual contents of the swill-tub properly so-called to economic account it was seen that certain plant would have to be installed, although investigation revealed that such appliances need neither be elaborate nor expensive. The suggestion was thoroughly ventilated, and as a result it was decided to approach the authorities with a proposal which was decidedly novel and which was certainly unprecedented.

Convincing facts and figures were obtained to indicate what the probable yield from this latest endeavour to turn military waste to profitable account would be. These estimates took into consideration the expenditure incurred by the acquisition and operation of the plant adopted.

The proposed outlay was not heavy, but it was felt by those who had elaborated this latest scheme that to request the authorities to incorporate it as part and parcel of existing military routine would defeat the primary principle underlying the idea. It was felt that, if the enterprise could be rendered profitable under military conditions, it might lead to its practical application by the civil community. The impression obtained that the few thousand pounds capital expenditure which would have to be incurred, together with the revenue, would be lost among the maze of millions sterling incidental to current military expenditure, even if it did not suffer actual inclusion, from its comparative triviality, among "sundry expenses." In this event all the lessons to be derived therefrom would be lost. On the other hand if the enterprise could be kept separate and could be conducted, as desired, along accepted commercial lines, success would impress the civilian, and might assist in persuading the municipal and other authorities to do likewise with the similar raw materials available in plenty from domestic sources of supply.

Thereupon it was suggested that the War Office should sanction the formation of a limited liability company to handle this latest exploitation of the actual swill along orthodox business lines. To allay any suspicions of private interests profiteering at the expense of the tax-payer it was recommended that the whole of the capital should be subscribed, and held, by the authorities, who should also be invested with the power to appoint the directors, and who should hold office at the pleasure of the War Office.

The novelty of the proposal was conceded, but the promoters were so sanguine of achieving success that the requisite sanction was extended. Thereupon a company was duly registered at Somerset House in due compliance with the law, with its articles of association complete in every respect, under the title "Army Waste Products, Limited," with a nominal capital of 7s. ($1.75)! That company proved an overwhelming successful venture from the country's point of view. Its results conclusively demonstrated the fact that there are literally millions in waste.

Small plants were established in military camps in several parts of the country, and subsequently the system was extended to the army in France, while the American

Expeditionary Force, impressed with its achievements, embraced the scheme and the plants employed. Operations were not confined to the treatment of the despised contents of the swill-tub, but also to the recovery of waste gravy and fats from the plates, the reclamation of bread-crumbs from the table, sweepings from the bakery and stores, and of odd crusts which heretofore had found no application other than as food for the wild birds, as well as the treatment of bones before they were handed over to the degreasers.

A policy of rigid commercialism was introduced and sedulously followed. The contents of the swill-tubs, as well as all other waste described above, were purchased, the prevailing prices being paid so that other commercial concerns were denied the opportunity of preferring the charge of unfair trading. Items of rental, wages, as well as maintenance, depreciation and capitalization charges were also taken fully into account, while the resultant products were also sold at market prices, which, as subsequent results revealed, left an ample margin of profit.

The plant employed, as well as the procedure followed in reclaiming and working the wastes up into raw material for industrial uses, possesses many interesting features, and are fully described in the next chapter.

CHAPTER IV

THE RECLAMATION OF MILITARY ORGANIC WASTE

In deciding the type of plant suited to the recovery of military organic waste regard was specially devoted to two governing principles. The one was the standardization of plant, so far as was practicable, to facilitate duplication and installation of the machinery in the various camps. The second was the selection of such plant as could be installed readily and cheaply in an improvised building, and which, if the conditions warranted, would enable a standard type of cheap and simple building to be adopted.

So far as the initial plants were concerned dependence had to be placed upon existing structures, otherwise delay in putting the scheme into practical application would have been inevitable, owing to the difficulty attending the acquisition of constructional material. But the installation of the plants in extemporized buildings sufficed to establish the applicability of the idea to any type of building of adequate dimensions, and in such a manner as to impose only the minimum of structural alterations to secure the requisite efficiency. This adaptability is an outstanding feature, because it indicates how the recovery of organic waste may be attacked along the most economical yet comprehensive lines, and with the minimum of capital expenditure and its concomitant amortization charges.

Two types of plant were adopted, both being standardized. One coincided with what might be described as the central or permanent waste-recovery station, while the second presented all the necessary elements of portability with the added advantages of inexpensive dismantling, removal, and expeditious reassembling at another point according to exigencies. But the processes are common to both types.

In the case of the permanent mill which I visited structural alterations had been reduced to the absolute minimum, the most conspicuous outlay being the provision of a simple form of elevator to lift the swill to a level above the plant to permit of gravity feed. The total cost of this station, including the installation of the necessary machinery, which included a steam-boiler, bone-crusher, small engine, melter, centrifugal or turbine fat extractor, and settling tanks, with one or two further accessories, was only £2,500—$12,500.

The swill is brought to the mill by motor-lorry. Operations are commenced at an early hour, because health considerations demand that waste of this character shall be handled with all possible promptitude in a big camp. The clearance is carried out daily and is complete, including all garbage, bones and other profit-yielding organic residue from the cook-house. Segregation is conducted as far as practicable at the source, special sanitary vessels for distinctive residues being provided. The mill continues working throughout the day until the whole of the morning's collection has been duly treated. No accumulation or carrying-over of some of one day's swill to the next day is permitted. Swill is susceptible to speedy fermentation, especially during hot and sultry weather, and so would become noisome within a very short period, as well as developing into an ideal breeding-ground for flies and other pests.

The contents of the collecting lorries are distinctly heterogeneous, the vehicles being laden with swill, bones, empty tins, jam and pickle jars, bottles—in short, anything possessing an element of salvage value. In segregating the waste at the cook-house special stress is laid upon the necessity to keep all green vegetable matter, such as outer leaves, stumps and other inedible trimmings, distinct from the general swill for the reason explained later.

The swill is transferred by the elevator to the upper level, where it is dumped into a capacious sink to drain. The proportion of free liquid is not pronounced, the swill being rather in the nature of a slush, whatever fat there may be present, apart from the solid pieces, being either congealed in flakes and globules, either free or clinging to the more stable substance. The superfluous water having

run off the residue is permitted to fall through a trap into a hopper feeding the capacious cooker or melter. Where the height of the building does not permit the provision of an elevated draining sink the swill, dumped at ground-level, is shovelled into the melter.

The melter is a cylindrical vessel or drum fitted with a steam jacket, the steam circulating at a pressure of about 80 lb. per square inch through the annular space between the inner and outer jackets. The capacity of the vessel is approximately 1,700 pounds, and the contents are kept agitated during the process by paddles mounted upon a revolving shaft forming the longitudinal axis of the drum.

The cooking process drives off all remaining moisture in the form of steam, and, at the same time, liberates whatever fat may be present by melting and rendering it fluid. It gravitates to the bottom of the cylinder to make its escape through a suitable vent and pipe into the settling tank. The last-named is also steam-heated by a coiled pipe system which not only sterilizes but clarifies the reclaimed fat, which is then permitted to cool and to solidify.

The swill remains in the drum for 70 to 90 minutes. By the end of this period the contents have been practically cooked, while all free fat has effected its escape. It will be observed that the steam does not come into contact with the contents, but is confined to circulation between the jackets. When withdrawn from the melter the swill resembles a stiff slush. This is transferred to a canvas bag to be dropped into a wire cage forming the inner vessel of the second machine, which is a vertical turbine extractor. The vessel when charged is closed by clamping down the lid.

Steam is turned on and the second stage of the fat reclamation process proceeds. Beneath the wire cage a series of steam jets are radially disposed in such a manner as to allow the steam to impinge upon the cage at an angle. The cage itself is supported freely upon a suitable vertical shaft and so, under the impetus imparted by the steam issuing from the jets, naturally revolves. By varying the volume and pressure of the steam the revolving speed of the cage may be varied within wide limits. Consequently it is possible to give the cage a very high rotary velocity.

The steam, after performing its mission towards rotating the cage, is induced to ascend in such a manner as to permeate

the contents of the canvas bag imprisoned within the wire cage. All fatty matter still associated with the organic material, owing to the high temperature of the steam, becomes still more fluid. Under the centrifugal action set up by the high rotary speed of the cage this fat becomes separated from the solids to be expressed through the pores of the canvas container and also the perforations of the outer cage, and to be flung against the inner wall of the extractor. The extreme fluidity of the very hot grease facilitates and expedites this separation, the expelled fat finally dropping to the bottom of the vessel to make its escape through suitable drain holes to pass into the settling tanks previously mentioned.

Under the whirling action of the turbine quite 91 per cent. of the fatty content of the mash is extracted and recovered. The treatment in the turbine extractor is continued until the flow of grease to the settling tanks is observed to cease, when steam is shut off and the extractor is emptied. The mash, somewhat resembling peat in consistency and of a rich chocolate colour, cooked through and through, is spread upon the floor to cool. Unless one has followed the cycle of operations one would never associate this odourless, clean, dry and sterilized product with the repulsive looking slush from the swill-tubs which had entered the mill barely two hours previously.

This residue constitutes an ideal pig-food. It is rich in the essentials for building up the frame and flesh of the porker, and as may be supposed finds a ready sale. It appeals to the farmer because it is clean to handle, is easier to transport than the conventional swill, because it can be bagged, while it possesses excellent keeping qualities. In effect it is a concentrated food, and accordingly can be broken down by blending with ordinary swill to increase the calories of the latter as they affect the pig, or it may be used instead of pig-meal, for which it is an excellent substitute.

Finally, it meets with the farmer's favour because its fat content, being only about 9 per cent., coincides more closely with the animal's dietetic requirements. It is not surprising, in these circumstances, that the farmer should be eager to procure as much of this sterilized food as he can obtain at a fair price. Certainly the authorities experi-

ence no difficulty in regard to its disposal at a remunerative figure.

The bones, upon reaching the mill, are dumped apart. They represent waste from the cook-house stripped as cleanly of meat and fat as a sharp knife in dexterous practised hands will allow. Their gravy-yielding and other nutritious constituents have been extracted from prolonged sojourn in the stock-pots. When they reach the swill-mill they appear to be as capable of rendering any further contribution to the general scheme as those bones which have passed through the hands of a frugal housewife. They have reached the stage when such refuse is either thrown into the kitchen fire, dust-bin, or handed over to the peripatetic rag-and-bone monger.

Yet they still possess distinct fat value, but it can only be wrung out by drastic effort. The bones are first passed through a crusher to be reduced to small size. At times the bone-dump from the cook-house will be found to be swollen by the dismantled framework of what was once a horse or some other animal, and which is to be passed through the fat reclamation factory. The crushed bones are submitted to the same process as the swill, being passed through the melter and extractor successively. The combined action of cooking and whizzing brings about a far more impressive release of fat than may possibly be imagined. Furthermore, cooking and whirling effectively release all slender strings and shreds of fat which may have escaped the butcher's sharp knife, while clinging tatters of meat and sinew are also thoroughly cooked. Upon withdrawal from the extractor the bones are thrown over a riddle, this action being sufficient to detach all shreds of fibrous matter which fall through the meshes of the sieve.

The bones are now ready for dispatch to the degreasers. The loose fibrous residue resulting from riddling is collected for subsequent use in the preparation of poultry foods Seeing that the treatment of the bones in this mill is pursued for the express purpose of reclaiming only the loose and easily secured fat and grease there is no conflict with industry. The degreasers are concerned rather with the recovery of fat resistant to ordinary salvage methods, as well as glue, size, and many other commodities involving the submission of the bone waste to many special processes, the ultimate residue being ground up to form a fertilizer.

The fat, after cooking, clarification, and solidification, presents an attractive, odourless, sterilized mass. This is dispatched to the trade for resolution into tallow, glycerine, and the requisite basic material for the production of soap.

I mentioned that, in the segregation of the wastes at the cook-house, special emphasis is laid upon the necessity to prevent the combination of all green vegetable refuse with the swill. This is essential, because in the subsequent cooking operation the dye from the green waste is extracted as every housewife knows, and, mingling with the fat, will steep the latter a pronounced greenish hue. This detracts very pronouncedly from the value of the fat because the dye, being of vegetable origin, cannot possibly be eliminated in the subsequent manufacturing operations through which the fat is passed. On the other hand, the deep yellow tinge which is likely to result from the presence of curry waste in the swill is not deleterious because it can be readily discharged.

For some time the disposal of the green vegetable waste presented a thorny problem. Farmers were not prepared to purchase it with the ordinary cooked pig-food, for the simple reason that they already possessed a surfeit of this refuse in their fields. Cremation appeared to be the only possible solution of the difficulty, the accumulations being somewhat formidable, but as a result of experiment the difficulty was very neatly and profitably overcome. This garbage, together with other waste of a comparative character, is subjected to a desiccating process to yield a product which is adapted to association with other approved by-products, without depreciating the pecuniary or other value of the whole, for poultry feeding.

Both plant and processes are extremely simple. Nor is a pretentious staff required. Six men suffice to attend to an installation capable of dealing with the swill contributed daily by a unit of 15,000 men. One hand tends the engine and boiler for the supply of steam and power; two men are responsible for the conduct of the melter; while two additional men wait upon the turbine extractor. The sixth man is retained to operate the bone crusher. This staff need only be increased, as the volume of work rises from any accretion to the camp, to the extent of one man for every additional 5,000 soldiers.

The wastage of bread, for the most part inadvertently, is far heavier than may be supposed. Possibly the heaviest proportion of waste arises from unconscious crumbling of the article during conversation at the table. Observation revealed that the accumulation of such crumbs and crusts was pronounced, while it was also discovered that a heavy contribution was extended by the bakery as the result of cutting up the loaves. The loss of flour incurred during the preparation of the bread and pastry was also found to be appreciable.

Thereupon it was decided to reclaim all bread waste and flour residues. The crumbs, together with the odd crusts and other small fragments, are collected, while the bakery floors and tables are regularly swept to yield grist to the salvage harvest. Moreover, despite the observance of all possible precautions to avoid waste, accidents are unavoidable. Occasionally a batch of bread is ruined in the baking. Being unfit for human consumption it is handed over to the salvage department to be worked up into readily marketable products instead of suffering destruction as was formerly the practice.

Bread and flour waste is subjected to a simple and inexpensive roasting treatment and is then roughly graded. The larger fragments and condemned loaves are reduced to a convenient size, while the finer material is reduced to a meal. The granulated residue is absorbed by the firms specializing in the manufacture of compounded proprietary poultry foods, entering into the composition thereof to approximately 20 per cent., which experience has proved to represent an excellent balance. During the war this granulated waste, sold in bulk, realized about 1⅛d. (2¼ cents) per lb., plus an additional charge of 10 per cent. to cover administration expenses. The coarser grade of waste proved to be an excellent feed for horses—superior to oats—and consequently was somewhat in demand at 1⅝d. (3¼ cents) per lb., the availability of such feed during the period when horses were necessarily rationed owing to the shortage of the conventional feeding-stuffs being keenly appreciated. In this instance the extra charge on account of administration expenses was also made.

Other expressions of military "save-the-waste" activity cover the recovery of tins, bottles, and jars. But the diffi-

culties concerning transport somewhat adversely affected success in this direction for a time. The preserve and pickle manufacturers intimated their readiness to accept all bottles and jars owing to the short supply of new receptacles of this character, but for some time it was found impossible to spare the requisite carrying facilities. The provision of canned and bottled comestibles does not enter into the official scheme of rations, the supply of such articles, "extras," being conducted through the Navy and Army Canteen Board, which, as a protection, imposes a charge upon all jars and bottles sold to the canteen attached to a unit. As a result every care is observed to preserve these vessels to avoid any financial loss arising from their non-return. Consequently, consignments of empty jars and bottles are generally returned intact, such losses as are incurred being unavoidable, and, in the main are due to accidental breakage.

An effort was also made to discover a possible commercial outlet for spent tea-leaves. This beverage is particularly popular in the army, and the accumulation of this waste is enormous. At one period the Home Commands were called upon to handle over 13,500,000 pounds of this refuse a month. The thought was entertained that the extraction of the caffeine from this residue might prove a profitable venture, but the experiments were inconclusive, and so the proposal was abandoned. Then the circumstance that the tea-leaves carry a certain proportion of potash suggested another line of application—conversion into fertilizer. But here again success failed to be recorded. The profitable exploitation of spent tea-leaves still awaits conclusive resolution. But it happens to be one of those problems beset with supreme difficulties, while it is imperative that every precaution should be observed to prevent this waste finding its way into unscrupulous hands to be turned to base account to the disadvantage of the community.

I have already mentioned that, while every effort was made to recover the uttermost ounce of fat-yielding residue from the kitchens, every encouragement was extended to the troops to cultivate the consumption of the nourishing dripping. Although it would seem as if these two recommendations were in utter conflict, no such trouble as might have been anticipated has been recorded. The troops

appreciated the concession, and the request for this fat has led to considerable fertility of thought and individual resource among the officers of the various units. Such initiative received commendation from headquarters because it not only contributed to the economical consumption of food in the army, but reacted to the advantage of the civil population who, unable to obtain dripping owing to the rigorous meat rationing in operation, were compelled to depend upon butter and margarine for their fat requirements. The increasing consumption of dripping by the soldiers to whom it was readily available served to permit increased quantities of the restricted supplies of other articles to be distributed among the community.

In one cook-house I witnessed an interesting method to increase the dripping yield. A big pail had been filled with little shreds of fat and meat, shaved and scraped by the cooks from the bones of the freshly-cut-up quarters of beef. This pail was placed within an outer vessel containing water, the improvised double saucepan then being placed upon the hot stove. As the water boiled the fat clinging to the shreds of fibre dissolved, while the meat-juices also became dissociated from the fibre under the influence of the heat. Boiling was continued until the whole of the fat had melted, when the vessel was removed and set upon one side to cool. The fat solidified at the top to yield a fine chunk of appetizing rich dripping, while immediately beneath was a jellied mass of gravy and disintegrated meat-fibre, forming a concentrated beef-tea. The dripping was reserved for issuance in lieu of butter and margarine, while the jelly sediment was set upon one side to improve the contents of steak-pies, puddings, and other savoury dishes.

The soldier is also a gourmet for cheese. But exigencies of war speedily elevated this comestible to the status of a luxury, even in the army. Unfortunately the average cheese does not lend itself to economic use. It is friable, the loss in crumbs being somewhat pronounced, while the rind is lost.

An officer conceived an ingenious idea to persuade the cheese to go farther, and in such a manner as to eliminate all possibility of waste. A whole cheese was taken, thoroughly washed and cleaned. It was then placed in a mill with a quantity of dripping, the proportion being 60 per

cent. of the former to 40 per cent. of the latter. The two constituents were then pulped and blended together.

The resultant product was distinctly surprising. The cheddar cheese was converted, by compounding with the animal fat, into a delicious cream-like article of the consistency of butter, allowing it to be spread upon bread and biscuits. The flavour was distinctly improved; indeed, the soldiers expressed a decided preference for this blended food. Its nutritive value cannot be gainsaid, because it carries all the virtues of the cheese plus those incidental to rich animal fat.

By this simple expedient all wastage of cheese was overcome. Even the rind, generally conceded to represent the richest part of the product, was used, being thoroughly disintegrated, macerated and blended with the dripping by passage through the little mill. Not only did the officer reduce the item for the consumption of cheese by his unit to a very significant degree, but he achieved the desired end without penalizing the men to the slightest degree.

The process is so simple that it might even be emulated to profit by the thrifty housewife. The kitchen mincing machine will suffice for the purpose. It is only necessary to pulp and to blend the two constituents thoroughly together. It certainly offers a means of inducing a pound of cheese to go as far as, if not farther than, a pound and a half has ever gone before.

In so far as the arrest of the elusive fat was concerned there remained only one other possible avenue of escape demanding interruption. This was the sink where all plates, dishes, and cooking utensils in general are washed. In the first effort to secure this contribution the hot water carrying the desired material was led into a pit. Here the fat collected in the form of a scum, which was skimmed off at intervals and sent to the swill mill for further treatment. But this crude method gave way to one more in consonance with modern ideas. The fat is now caught at the gully.

One device I saw installed to achieve this end was of an extremely simple character. It comprised a wooden box, about three feet in length by one foot in width, and about two feet in depth. It was subdivided into three cells by two partitions, which, however, did not extend to the full

depth of the box. The pipe from the sink entered the box at one end while the outlet to the drain was placed at the opposite end. The box was filled with cold water, which need only be renewed when the box is emptied for cleaning and flushing, since normally it is kept charged with the water coming from the sink. The hot water bearing the fat circulates through the three cells and finally, upon reaching a certain level, passes into the drainage system.

But during its passage through the box the hot water becomes so effectively chilled as to be compelled to release any fat which it may be carrying. This congeals and rises to the surface. Within a short time the top of each cell is crusted with a thick layer of solid fat which may be removed as frequently as desired. The box not only constitutes an efficient and simple, as well as inexpensive, fat-trap, but also acts as a water seal to the sink, thus preventing all nuisance or fouling of the sink pipe.

The amount of fat capable of being retrieved in this manner is certainly startling. The fat-trap which I saw fitted to one of the sinks of an army cook-house yielded several pounds of fat every day—sheer waste recovered from washing plates, pots and pans. The fat is dispatched to the swill-mill to be passed through the melter and extractor in the usual manner, thereby undergoing thorough clarification and sterilization. The recovery during the course of the year of several thousand pounds of fat which otherwise would have vanished down the drain, by the introduction of a small wooden box such as I have described, represents no mean achievement. Certainly it serves to bring home the losses which are incurred at this point in every house during the twelve months. The device might profitably be installed at every sink by every householder. The few shillings involved by its provision would be quickly recouped, because the fat always has a market. Moreover, the introduction of this device would contribute towards the efficiency of the drain, keeping it clear and free to fulfil its designed function.

That it pays to recover all fats and greases lost to consumption or permitted to escape because it is merely residue is conclusively borne out by the results recorded in connection with the military operations which I have described. During the year 1917 the fats—waste—reclaimed from the

Home Commands of the British Army yielded 13,000 tons of tallow. The value of all the by-products recovered from the refuse was £700,000—$3,500,000. The cost of securing this waste for commercial exploitation, including the extra pay extended in the form of bonus to the cooks, and other allowances, was £400,000—$2,000,000—leaving a balance of £300,000—$1,500,000—which was returned to the public.

As previously mentioned, the fats were urgently needed to furnish glycerine for the manufacture of munitions. One ton of crude fat yields 10 per cent. of glycerine, so that 1,300 tons of this indispensable article were derived from this one source of supply The fat was sold to the bone-degreasers and the soap manufacturers, who effected the recovery of the glycerine, selling the product to the Ministry of Munitions at the agreed price of £59 10s. to £63—$297.50 to $315—per ton, as compared with £300—$1,500—per ton which we should have been compelled to pay had we bought the glycerine upon the open market.

Here was a direct saving of £237 to £240 10s.—$1,185 to $1,202.50—per ton. Altogether the purchase of glycerine recovered from military organic waste represented a saving of £312,650—$1,563,250—because the nation obtained for £77,350 — $386,750 — what otherwise would have cost £390,000—$1,950,000. This figure is not quite complete because, inspired by the success achieved from the milling of the swill at home, the army in France established similar stations behind the lines upon the other side of the Channel. When these were brought into operation the shipment of fat and grease recovered from the organic waste of the British Expeditionary Force in France represented 5,000 tons a year, whence 500 tons of glycerine were derived. The 5,000 tons of fat won from the swill-tubs of the army in France realized £140,000—$700,000—while the total saving recorded under the heading of glycerine secured from army waste fat was augmented to £432,000—$2,160,000. During the year in question the aggregate financial economies directly secured from the exploitation of organic army waste, in conjunction with the introduction of ways and means to reduce the yield of such residue from the observance of improved culinary methods and reduced consumption of foodstuffs was approximately £5,626,000—$28,130,000.

Finally, to demonstrate the value of this contribution to the aggressive resources of this country, it may be stated that the 1,800 tons of glycerine derived from the 18,000 tons of tallow recovered from the army swill-tubs, rendered it possible to turn out sufficient nitro-glycerine to serve as the propellant charges for 18,000,000 eighteen-pounder shells.

The success accomplished with the army waste fat and grease prompts the obvious inquiry as to why comparative methods cannot be adopted in civilian circles. The average household has but little conception of the value of its fat losses. It should not be an impossible task to segregate the waste from the house at the source, and to submit it to similar treatment. The majority of our civic and municipal authorities possess buildings which could readily be adapted to the installation of the necessary plant, and the capital outlay therefore need not be heavy. The disposal of the various by-products would not be attended by any difficulty. True, under war conditions abnormal prices ruled, but even to-day they are attractive and are likely to continue to remain so for an appreciable time to come.

Of course, the municipal authorities could not aspire to net such profits as are possible in the army. In the first place the wage problem must be taken into consideration. Under military conditions this does not arise. Fatigue parties are always available to collect the swill and to conduct its conversion into fat. But even if the practice were pursued at a loss it would redound to the distinct benefit of the community in general, because it would comply with one of the fundamental laws of National Economy and would conduce towards the reduction in the cost of living. But unprofitable exploitation would not result so long as the methods were conducted along commercial lines. Ineptitude and wastage in administration and operation alone could be responsible for any such eventuality in this connection. Happily we are becoming wiser in our knowledge: domestic organic waste is now being exploited on broader lines, as I relate in subsequent chapters.

CHAPTER V

INVENTION IN ITS APPLICATION TO WASTE RECOVERY

THE necessity to conserve our industrial resources, which is so pronounced to-day, is acting as a powerful stimulant to inventive effort. The mere circumstance that approved apparatus exist for the reclamation of wastes and are readily available to those of a thrifty or enterprising turn of mind no longer suffices to meet the situation. In the past we have been content to practise waste recovery along what may be described as satisfactory lines, but satisfactory only in so far as they represented an attempt to turn refuse to commercial account. In many instances the appliances employed have only been extemporized and, as may be imagined, are far from being efficient. They only enable a certain proportion of the available materials to be recovered. In many instances residues treated for fats have carried away just as much of the essential article after treatment as were actually recovered. In other words, the work was only half completed: the system followed has been unable to give a higher yield owing to errors in its design and construction.

Waste recovery as it should be practised to-day is a science. It is just as precise a science as the extraction of nitrogen from the atmosphere, the smelting of steel, or the production of artificial silk. Hit-and-miss methods may have sufficed during the years when commodities were cheap and plentiful, but to-day there is a world-wide stringency in the supply of anything and everything necessary to commerce. As a consequence prices are ruling high, and so the practice of waste recovery along extremely well-defined scientific lines is essential.

The harnessing of science to this peculiar industry is imperative for more reasons than one. As the process of extraction, say of fats, is pushed to its logical conclusion, the task becomes more and more exacting and expensive, demanding the employment of refined methods. It is far more difficult to draw from the material the last ounce of possibly reclaimable fat than to whip out the first ounce. The last-named is surrendered readily, but to recover the first-named enormous persuasive effort is entailed.

But it is the uttermost ounce which the scientist is determined to obtain. Easy conquest does not appeal to his well-ordered mind, and so we see a spirited struggle in progress to increase efficiency. At the same time in attaining this eminent factor the inventor must keep his eye and hand upon the issue of cost. If it is going to cost more to extract the last absolute ounce than that ounce is worth, then the effort is futile. Commercialism, which considers inventive ingenuity merely from the angle of pounds, shillings and pence, or dollars and cents as the case may be, is not impressed by the mere beauty of any process or apparatus.

The financial issue is surveyed from every possible angle —capital outlay, fuel consumption, simplicity of operation, maintenance charges, depreciation, renewals, and labour. Any one of these several factors may be sufficient to cause the refusal of an advocated process, while should they be experienced cumulatively then the likelihood of the process being adopted is extremely remote. Waste recovery is such a sensitive range of endeavour as to prevent all consideration along philanthropic lines.

An instance in point may be narrated to indicate how perplexing and intricate the problem is. As is well-known, wood, in common with all vegetation, carries a certain proportion of alcohol, a product in keen demand for numerous industries. It is also common knowledge that in working wood enormous waste is incurred, notably in the form of sawdust. This fact induced inventors to attack the problem of extracting the alcoholic content from this residue. Laboratory experiment confirmed the practicability of the project, and even went so far as to indicate how the idea might be commercially developed.

But there is a tremendous gulf between the laboratory

and the factory. It was many years ago that the possibility of extracting alcohol from wood first aroused the serious attention of the industrial chemists. They are still wrestling with the problem. Time after time the world is startled by the announcement of a new and inexpensive process for the distillation of alcohol from wood and the prospect of extracting whisky and other popular beverages from sawdust excites intense interest. But, metaphorically speaking, nine days later a strange silence is encountered. The new process has vanished from aught but a memory of much claimed but nothing forthcoming. Fortunes have been sunk and lost in the attempts to solve this momentous problem, and it is probable, from the state of knowledge and the stage of experiment at the moment attained, that many millions more will be expended before commercial success is achieved. One of the greatest obstacles to the realization of the chemist's dream has been the extremely high temperatures to which resort has to be made, which plays sad havoc with the plant involved, and the charges incident to the renewal of which are so heavy as to render the financial outlook extremely depressing. Even the conditions of war, which scouted all considerations of expense, have not carried us an inch forward. We built one factory to conduct the distillation of wood for the alcohol which was so sorely needed, and planned a second installation. The first factory was promptly abandoned after the signing of the armistice, while the second factory was never completed, owing to the indifferent results achieved with the conduct of the initial plant.

Similar experiences may be narrated in many other fields of attempted waste recovery. Fortunately, however, for every dismal failure recorded a dozen or more overwhelming triumphs can be related. It is this circumstance which induces the experimenter to persevere upon his ventures of discovery. But this is not the only satisfactory feature of success in this field. The spirit of rivalry is so keen that the industrial chemist and the chemical engineer are for ever striving might and main to improve the methods which they have evolved, and in the determination to secure the uttermost ounce of the elusive fat, they proceed to extreme lengths. The eternal quest for improved efficiency is not confined to the extraction of fats; it is equally appli-

cable to the recovery of other products in keen demand and commanding an attractive market price, but I select fat as an example because it is familiar to all.

Moreover, in elaborating his fruitful thoughts the investigator is compelled to bear in mind varying conditions. Accordingly he must adapt his ideas to the prevailing requirements. Obviously it would be inexpedient to concentrate perfecting effort upon one definite system. The plant involved may necessitate a capital outlay possible only to the wealthy firm or city, and utterly beyond the small man anxious to embark upon such an enterprise, or be impracticable to the average town, to which the plant, owing to the limited volume of material to be handled, would never justify the probable expense.

In these circumstances we see plants and methods being adapted to varying demands so that the reclamation of the urgently required fats, oils and greases may be pursued by one and all. In a previous chapter, describing the recovery of these commodities from the swill-tubs of the army, I referred to one system which is wholly mechanical in its operation. In this instance success depends essentially upon the centrifugal turbine extractor or "whizzer," which it must be admitted has proved exceedingly attractive in application. For this reason the "Iwel" system, as it is called, has met with conspicuous success and wide application, being found in every industry.

But there is another system, or rather wide range of systems, known as the Scott, differing entirely from the one already mentioned. This, too, is of British origin and construction, and compels attention from its applicability to every possible requirement as well as adaptability to every conceivable condition, from the factory handling only a few thousand pounds of miscellaneous fat-carrying refuse a day, to the huge packing plants to be found upon the American continent, both North and South, Australia and New Zealand, where the accumulations of fresh fat are imposing, and where the necessity for prompt big-scale treatment to secure the attractive prices ruling for high-grade fats is so obvious. The operations of the firm under review demand additional attention inasmuch as, through the combined efforts of its chemists and engineers, it has been able to evolve and perfect a process which is distinctly

remarkable, seeing that it enables all but 1 per cent. of the fat contained in the crude refuse to be reclaimed, and in such a manner as to render the method completely profitable.

The Scott systems, fundamentally, are three in number. In the one the waste animal products are digested with open steam in conjunction with a vacuum; the second method comprises the *dry* rendering of edible fats under vacuum; while the third practice is the extraction of the grease by what is known as the solvent system. Each possesses its individual features, making direct appeal to the situation to which it is most eminently adapted, and, to a certain degree, the three respective methods may be said to represent an equal number of progressive strides towards maximum efficiency, with the solvent process constituting the pinnacle of success so far achieved in this province from the simple fact that it reduces the loss of fat to 1 per cent. absolute.

However, it is difficult to lay down any hard-and-fast rule concerning the selection of any of these three processes because, in deciding a question of this character, full consideration must be given to the class of material to be handled. For instance, although the dry rendering system under vacuum is especially applicable for the reclamation of edible fats, it is not to say that the first, or open steam, process is only adapted to the production of non-edible fats. As a matter of fact there are certain classes of offal which are not suited to dry steam rendering. The fat contained in such refuse can be most advantageously extracted only by the open steam process. This particularly applies to the offal produced in the large killing establishments, where such refuse can be dealt with in the fresh condition.

The dry steam rendering process is particularly applicable to the production of fine or high grade edible fats. The finest fat recovered from an animal source is that known as "Oleo" margarine or "Premier Jus." This is rendered from the very finest crude fat obtainable, and in order to ensure super quality being obtained the conventional treatment is one demanding extreme care so that its inherent qualities may not suffer the slightest injury. The general practice is to mince the raw material very finely and then to treat it in hot water-jacketed pans at a very low temperature, every attention being observed to prevent the tem-

perature rising above a rigidly predetermined point. In these circumstances it will readily be observed that the process is necessarily somewhat costly and occupies appreciable time. But by means of the dry rendering process under vacuum the raw material may be subjected to very high temperatures, and that without the product being impaired in any way. In fact, it is equal in every respect to that obtained by the orthodox process, while, of course, it is far more expeditious and cheaper.

The plant necessary to the vacuum system is simple. It comprises a cylinder or boiler called a digester, into which the offal to be treated is placed. Under the wet steam process and after the vessel has been closed a vacuum is created. Open steam then is admitted into the digester and in such a way as to enable the steam to pass upwards through the mass, thereby thoroughly permeating it. Naturally the hot steam renders the fat fluid, that which is free running readily to the attached tanks.

Rendering is conducted under a pressure varying from 20 lb. to 40 lb. as the case may be, but the lower the pressure the better. The application of the vacuum to the process constitutes the crux of the invention. At first sight the advantages of the principle may not be readily apparent, but they may be simply explained. In the first instance the creation of vacuum conditions effects the removal of the greatest obstruction to the influence of heat, namely air. If this be eliminated cooking can be conducted at a much lower temperature than would otherwise be practicable. Fat, indeed all animal matter, carries a certain proportion of moisture and this must be withdrawn before the actual release of the commodity can be effected. In vacuum water boils at a temperature below one-half of that required at ordinary atmospheric pressure. In other words, instead of the boiling-point of water being 212 degrees Fahrenheit, as is the case with the kettle on the hob, it will boil at less than 106 degrees Fahrenheit. Consequently, if a high vacuum be established within the digester the latent water can be converted into steam to assist in the melting process proper, which then can be conducted unhampered. Temperature, moreover, exercises a decisive influence upon the quality of the product, this being very superior in quality when the recovery is carried out at a low degree.

Another point to be noted is that all noisome odours which are thrown off during cooking, and which cannot be avoided, are exhausted from the vessel. They are not allowed to escape into the open air, but are led to the furnace to be discharged into the hottest part of the fire. They have to ascend through the incandescent fuel resting upon the fire-bars, and, since they are not allowed to become mixed with air, must undergo complete combustion. Consequently no pollution of the atmosphere can possibly result from the treatment of even the most rancid offal. It being impossible to construe the operation into a nuisance, the plant can be installed at any convenient point even in a densely-settled area in safety, because the system fully complies with all the rigid requirements of the local sanitary authorities and health officers. This is a most important feature and one which will be readily appreciated when one recalls the insufferable conditions precipitated by the recovery of fats and greases from refuse under the old systems.

But the outstanding characteristic of the vacuum system is the increased yield of fat forthcoming. No mechanical system, whether it be pressure or high-speed whizzing, can extend completely satisfactory efficiency results. As is well known, the fat entering into the constitution of animal matter is contained in myriads of minute cells which are surrounded by tissue. The walls of these cells are exceedingly elastic and of prodigious strength. They may be compressed to an inordinately intense degree in a press, or distorted and stretched by recourse to centrifugal action without breaking. It is this circumstance which reacts against a high recovery of fat by recourse to pressing and whizzing because the cells cannot be induced to burst.

When a vacuum is applied a totally different result is recorded. The application of heat causes the fat and air within the tiny cells to expand, and in this manner the walls of the cells become distended to the limits of their elasticity. The removal of the surrounding air within the vessel by the vacuum pump completely upsets all equilibrium. The air pressure within the cells is higher than that applied from without, and consequently there results an accentuated expansive effort within the cells. But the tissue has already been stretched to its utmost limit, and

so being unable to withstand the increased strain imposed collapses, thus releasing the imprisoned air and fat. Under the vacuum process the disruption of the fat-carrying cells is complete, and this explains why an augmented yield of fat is obtained by this method.

Under the open steam vacuum process the actual practice is to apply the vacuum three times at intervals during the operation. The first application serves to remove the obstructive air to facilitate and expedite cooking of the contents. The second brings about the disruption of the cells and the release of the fat which they contain. The third application of the vacuum, which is effected towards the end of the process, effects the withdrawal of the foul vapours arising from the digesting operation and their discharge into the fire.

Owing to the steam being admitted to the digester and being allowed to come into direct contact with the mass, the residue upon withdrawal is wet. The grease, which has been rendered fluid in the process, has escaped from the digester through a suitable draining pipe into a tank where settlement and clarification are carried out. But all the grease cannot be recovered in this manner. A certain proportion, notwithstanding the disruption of the fat cells, is held up in the mass and can only be recovered to an appreciable degree by submitting the residue to treatment in a press. In this way the greater part of the remaining fat suffers expulsion and recovery. The wet cakes upon removal from the press then have to be dried and disintegrated.

The dry vacuum process, which is essentially adapted to the rendering of edible fat, has many advantages over the wet steam method. Whilst the plant employed is broadly similar to that employed in the process already described, there is one notable difference. The digester is enveloped in an outer shell or jacket, and the steam is circulated through the space between the two walls. It is not brought into contact with the contents of the digester at any stage of the process. The action taking place within the vessel during the operation is precisely the same as when the steam is brought into direct contact with the refuse, the fat being rendered fluid by the heat and the cells undergoing disruption by the creation of the vacuum. A high vacuum is maintained throughout the whole render-

ing process. Consequently the moisture inherent to the raw material is withdrawn as rapidly as it is converted into steam, resulting in the production of a fine edible fat totally free from moisture. Moreover, the residue withdrawn from the digester at the end of the process, known as "crackling" or "greaves," is likewise quite free from moisture, although, as in the case of that resulting from the open steam process, an appreciable proportion of fat is held up in the mass which can only be recovered to a pronounced degree by the application of pressure.

The dry steam or jacketed vacuum process is especially adapted to the treatment of fresh fat waste, the reclaimed product of which is primarily intended for the preparation of edible foodstuffs, such as oleo-margarine. By carrying out reclamation without bringing the steam into contact with the fat several distinct advantages are obtained, the most important being the retention of the natural properties of the fat, and no loss of glycerine which otherwise is inevitable to a certain degree. Consequently, it is an ideal process for the treatment of the "Premier Jus." There is no need to mince the fat finely, as in the orthodox rendering process, it being necessary only to cut the waste roughly for charging the digester.

A special press has been devised for the treatment of the crackling or greaves. It is of the cage type which allows the fat, during pressure, and which operation is carried out while the residue is very hot, to be expressed between the bars of the cage to fall into a trough for recovery. The cakes, after pressing, are dry, excellent in quality, light in colour and of attractive flavour, a result due to the fact that the tissues have not been scorched or charred in any way during the rendering process. The greaves constitute an excellent ingredient for the preparation of kennel and poultry foods, and enter extensively into the manufacture of dog-cakes. In a few instances the dry greaves, owing to their high nutritive value, are served to the kennel in the straight form as they issue from the press.

While the dry vacuum process is certainly efficient, it does not fully comply with the latest ideas pertaining to the recovery of fats from organic waste. The press is the weak link, because thereby it is only possible to recover a certain proportion of the fat held up in the mass, even when

the cellular construction has been completely broken up. It is stated, as a result of accumulated experience, that the amount of fat left in the greaves may run up to as high as 10 per cent. of the original fatty content of the offal: in many instances it has been found to range as high as 20 per cent. The fact that this remaining fat defying reclamation by pressing must be relatively high is evident from the readiness with which certain waste exploiters will buy up the greaves, not to turn them into kennel and poultry foods, but to submit them to further treatment in order to wring out still more of the fat which they carry.

This manifestation of enterprise has been rendered possible by the advance of the science of fat recovery from offal to such a level as to enable 9 per cent. of the fat remaining in a 10 per cent. greaves to be extracted. It is the prevailing high price commanded by fats which renders such additional treatment upon an extensive scale so attractive and eminently profitable.

The process in question is the Scott solvent recovery invention to which I have referred, and which represents the greatest achievement yet recorded in the whole science of fat reclamation from organic waste. The process was perfected and patented shortly before the war, and although hostilities militated against its immediate and rapid development, thereby delaying the recognition of its overwhelming virtues, it is satisfactory to learn that many plants operating upon this principle have been laid down, not only in this country, but in other parts of the world. It is the process which at the moment is arousing the most intense interest, owing to the progressive stride which it represents in this field.

The process is delightfully simple, although apparently it involves an intricate plant and demands a higher level of skilled labour, but where the work of reclamation is conducted along ambitious lines it cannot be excelled. Briefly described, it turns upon the employment of benzine, or some other equally volatile solvent which, as we all know, will readily dissolve fat and absorb it. What can be done with this agent is familiar to every housewife who practises the removal of grease spots and other unsightly marks from clothing by the aid of benzine, while it is the medium whereby dry-cleaning is rendered practicable.

The raw material—condemned meat, offal and other organs of the animal recovered from the slaughter-house which possess no edible value—is charged into a steam-jacketed horizontal extractor fitted with stirring gear. When condemned carcasses are to be treated there is no need to carry out preliminary deboning; it is merely necessary to reduce the material to rough pieces for convenience of handling. It will be observed that the steam is not brought into contact with the mass, but is circulated through the jacket as in the dry vacuum process.

The solvent is introduced in the first instance in the form of vapour, being passed through boxes of special construction, to pass finally into the extractor. The contents of the latter being in a condition of constant agitation as a result of the manipulation of the stirring gear, the benzine vapour is able to permeate the mass. The heat radiated from the steam circulating through the jacket converts the moisture present in the material into vapour and with which the solvent comes into contact. Vaporization of the moisture causes the solvent itself to condense to a certain degree, and in the liquid form it dissolves out the grease. The process is continued until the bulk of the moisture has been eliminated, when the grease and solvent are withdrawn. When the grease has been fully extracted down to a limit which will result in a dry meat-meal, containing about 1 per cent. of grease, the benzine is steamed off in the usual manner. The benzine itself is recovered because it is only permitted to work in a closed circuit, and, after fulfilling its purpose, is passed to a still to be cleaned and purified, after which it is again passed to the extractor to repeat the cycle of operation.

The process, it will be observed, is continuous, while the benzine may be used over and over again. All that is required is to place a sufficient quantity of the solvent into the circuit to carry out the operation with the essential efficiency. Naturally, the quantity involved varies with the size of the plant and the work to be fulfilled, but it may run up to 5,000 or more gallons. The plant is generally laid out upon the unit principle, which is the most satisfactory, because it facilitates the adaptation of the installation to the volume of work in hand. One or more units can be shut down during the "off" period, allowing the remainder

to be worked up to their full capacity, which, of course, is the most efficient and economical method. The losses of benzine are very low—not exceeding 1 per cent. of the weight of the raw material treated. In fact, there are many installations in operation where, over a period of one year, the benzine loss recorded is actually below 1 per cent. This factor is vitally influenced by the care and attention bestowed upon the plant. If it be carefully tended, all joints being kept in the tightly packed condition, and the condenser maintained in a high degree of efficiency, the benzine loss may be reduced to an infinitesimal degree, the value thereof representing but an insignificant fraction of the value of the increased yield of oil and fat.

The solvent acts upon the grease only. It does not affect in any way the gelatinous material, and, consequently, the nitrogenous or ammonia value of the ultimate meal is considerably enhanced as compared with the results achieved with the digesting plant. The meal is discharged from the extractor in a dry crisp condition ready for immediate grinding, and is admirably adapted for poultry and cattle feeding. No traces of the benzine remain.

The bones may be ground immediately, if desired, but if these should be forthcoming in sufficient quantity they should be passed on to the glue and gelatine plant. There is no necessity to submit them to a further degreasing process, because this has been completed in the one operation in the extractor. As a rule, however, with installations devoted to the treatment of condemned meat and other offal, the bones are not forthcoming in sufficient quantities to justify the attachment of a glue recovery plant although, of course, they can be sold to other works specializing in this work. It is merely a question as to whether it would pay to transport the degreased bones to the glue works. If not, they can be ground up to be utilized as fertilizer, for which, it is needless to say, a good price can be obtained.

The recovery of fat down to 1 per cent. of that contained in the crude material does not constitute the only outstanding advantage of the solvent extraction process. It enables the whole of the operations to be condensed into one task, completely dispensing with all auxiliary apparatus. The refuse is merely charged into the extractor and withdrawn in the form of powder, and, if condemned carcasses

have been exploited, bone as well. What this means may readily be realized. Under the open steam digesting system —even with the wet and dry vacuum systems to a lesser degree—the refuse must first be cooked. The material upon withdrawal from the digester must be passed through the press, after which treatment it has to be disintegrated and dried. If the reclamation of the gelatinous or "stick" liquor, as it is called, be part of the process this also demands handling. Thus one may safely anticipate having to conform with five distinct and separate operations, involving intermediate handling and supplementary plant, while the loss of fat in passing from stage to stage is far heavier than may possibly be imagined. But, with the solvent extraction process, the numerous above-mentioned operations are resolved into one, and one only—the charging of the extractor with the refuse. The saving in labour by the elimination of all interhandling is obvious, which in these days of enhanced wage costs demands consideration, while there are no intermediate losses of oil. In so far as saving of time is concerned there is little, if any, difference. Under the solvent extraction method a period of eight to ten hours is required to deal completely with a charge of 4,500 to 9,000 lb.

The fruits accruing from this latest manifestation of ingenuity in connection with the reclamation of waste may be tersely emphasized. The reclamation of the fat down to 1 per cent. being accepted, it may also prove interesting to indicate how effectively the nitrogenous or ammonia value of the product is preserved. The following represents a typical analysis of a meat meal, which, it should be pointed out, contains no bone whatever. The figures are :—

	Per cent.
Tribasic phosphate of lime (superphosphate)	3·25
Nitrogen	11·37
=ammonia..	13·81

At the large cattle-slaughtering establishments of North and South America, and at the sheep-killing stations in Australia and New Zealand, the residues from which the edible fat has been recovered by the open steam process are turned over to the solvent extraction plants which have now been introduced to form an integral part of the waste-

recovery system, the value of the invention being fully appreciated. At first the practice was to dry the residues from the digesters before committing them to the extraction plant, but since it was found superfluous to carry out such a preliminary, the residue is turned over from the open steam digester where the edible fats are obtained to the solvent extraction plant, the idea of course being to secure the proportion of fat escaping recovery in the digester. In this manner 99 per cent. of the fat contained in the crude waste is obtained, but the proportion reclaimed from the practice of the solvent extraction process is set aside for manufacturing purposes—conversion into soap and other utilitarian commodities.

In the course of digesting the fresh fat with open steam a considerable quantity of the "stick" liquor is precipitated, and its recovery for size is fully justified. In the crude form this liquor is somewhat weak, but by means of the Scott multiple-effect vacuum evaporating plant it can be concentrated to any required degree of density. This product is blended with the meat-meal from the solvent extraction plant in a suitable vessel and is then dried to a powder, the ultimate meal being high in ammonia.

In the case of the offal which is not suitable for the production of an edible fat, recourse to the open steam digester is eliminated. The refuse, along with the condemned meat, is consigned directly to the extraction plant to be dealt with in one operation. A similar practice is followed at the large pig-killing establishments. At one installation in South America, where there is an impressive illustration of British ingenuity and enterprise in regard to waste recovery upon the Scott principle, the tallow produced is immediately dispatched to the adjoining soap works—also a British installation—where the glycerine is recovered and soap is produced. In this instance therefore we have a powerful example of a self-contained establishment completely equipped for the recovery of the whole of the by-products incurred in the course of its normal operations and to the utmost advantage.

The Germans have been extremely active in advancing the possibilities of the solvent extraction process. Several large plants are in operation in the Fatherland, of which we heard a good deal during the war, but the character of the

operations of which were grossly misrepresented and exaggerated. Those behind the lines were reserved exclusively for the disposal of fallen horses as well as the offal and other wastes resulting from the feeding of the troops. The fat, immediately upon its extraction, was treated for its glycerine, which was dispatched to the explosive manufactories in Germany, while the residues were converted into soap upon the spot. This practice was followed because the glycerine was the staple in most urgent demand, and the transport of which was far simpler than the movement of the crude reclaimed fats. So far as soap was concerned the German soldiers, even up to the front lines, had little or no room for complaint, for the simple reason that it was prepared in their midst at the plants which were installed within easy access of the centres of suitable raw material supply.

British manufacturers, although somewhat conservative, are becoming alive to the fact that only by the solvent extraction process can the utmost wealth be won from fats derived from waste materials, and many interesting expressions of enterprise in this direction may be recorded. For instance, the manufacture of maize flour has made decided strides in these islands during the past five years, doubtless owing to the deficiency in connection with the wheaten product. However, before this grain can be converted into the farinaceous form the germ must be extracted, otherwise the keeping qualities of the flour are seriously impaired. But, seeing that the germ represents approximately 20 per cent. of the whole grain, it will be seen that the industry has to face a loss of one-fifth of its raw material in preparing the flour—an imposing quantity. However, the germ is rich in oil, this constituting approximately 20 per cent. of its bulk. The demand for oil, particularly those of vegetable origin, is such that the maize germ, instead of being turned over directly to cattle, is now being exploited for its oil. By the solvent extraction process 99 per cent. of this available 20 per cent. of oil is being extracted, the resultant meal thus being virtually free of oil.

When the idea was first taken in hand it was maintained that the withdrawal of the oil would imperil the feeding qualities of the meal residue. This being conclusively disproved it was then argued that the employment of benzine for the purpose would depreciate its cattle-food value, the

idea doubtless being entertained that it must be associated with a certain benzine flavour from coming into contact with the solvent. But here again practice did not coincide with precept, because horses will devour the meal, freshly drawn from the extractor, with avidity, and look round for more, proving very convincingly that the benzine is completely exhausted from the extractor after having fulfilled its designed function. Experience has shown that meal made from the de-oiled maize germ is every whit as good and as nourishing as, if not actually superior to, that which has not been subjected to the oil-recovery process.

The solvent extraction process has proved to be of incalculable value to the firms specializing in the dry-cleaning of clothes, fabrics, and textiles in general. When the articles are likely to be charged with appreciable quantities of dirt, such as carpets, they are first subjected to a dusting treatment which removes the superfluous or free dirt. Wearing apparel, except in a few instances, does not require submission to this preliminary operation and so is passed into the washing machine, which contains only benzine, together with a slight proportion of ammoniacal liquor. The garments are passed through several successive washings and rinsings in various machines, to be submitted finally to the hydro-extractor, where practically the whole of the benzine is recovered, the goods being delivered practically dry. But to be positive upon this point they are hung for three or four hours in a drying room. The articles are then examined for any stains, such as blood and grease marks, which have resisted elimination in the mechanical cleaning process. These are removed by hand—"hand-spotting" as it is called, either with water, or with benzine and a little soluble soap and a brush.

The dirt and other deleterious matter removed by the benzine in the washing and rinsing machines is separated from the solvent, which undergoes a simple treatment, bringing about its complete purification, when it is returned to the service-tanks for further use. The process is one of continuous distillation, the benzine, as previously mentioned, being used over and over again, it only being necessary to add certain quantities from time to time to remedy the unavoidable losses incurred. The wastage of benzine averages about 15 per cent. of the weight of the goods treated.

Seeing that about 4,500 gallons may pass hourly through the machines and the circuit, the loss is relatively low. The quantity of dirt removed, despite the thoroughness of the process, is comparatively trifling.

One interesting phase of the dry-cleaning process deserves mention, if only to bring home the assiduity with which the reclamation of grease from every conceivable source is now being prosecuted. Some of the firms are devoting attention to the separation of the grease removed from the clothes by the benzine. Seeing that the only likely contribution of grease is that removed from the hands or other part of the body coming into contact with the fabric, and that the grease in question is only natural perspiration, it will be seen that, under the most favourable conditions, such deposit must necessarily be exceedingly trifling. That it should be deemed worthy of recovery seems almost incredible. But it is being done, though the yield is low, and it is proving profitable.

Probably no other waste is to be found in such a multiplicity of forms and in such unexpected quarters as that capable of yielding grease, but that it should pay to recover natural perspiration to assist in the lubrication of a railway locomotive, or some other piece of machinery, serves to emphasize the extremely fine limits to which fat-reclamation science has been carried. It is admitted that, in the majority of cases, the possible yields are so small as to render reclamation absolutely impossible by any but the solvent extraction process, which undoubtedly constitutes the highest testimony to the efficiency and value of this wonderful British invention it is possible to advance.

CHAPTER VI

SAVING THE SCRAP FROM THE SEA

If the human race be extravagant in one, more than in any other direction, it is undoubtedly in connection with the utilization of the harvests of the sea. It is a failing as strongly asserted by the primitive as by the cultured races. The aborigine, when there is a big run, will trap as many fish as he can, not for consumption, but apparently for the mere sake of catching his prey. He will select what he requires and leave the remainder to rot. His civilized brother pursues a broadly similar course, only in this event decomposition may not be permitted to run its course without fulfilling a beneficial purpose. The process can be harnessed, as it were, to a more or less useful function.

Improvidence in the consumption of fish is particularly noticeable among those nations which are able to point to an extensive salt-water front, combined with a densely-settled population within a relatively small area. It becomes accentuated when the country is possessed of an intricate and excellent system of rapid inland transportation, allowing the prompt movement of the catches from the points of landing to the centres of consumption.

Such a country is Great Britain. With us fish is an exceedingly cheap food and one which, normally, is readily procurable in adequate quantities. The "long haul" by rail occasions no apprehensions, inasmuch as the railway transport problem, so far as fish is concerned, has been magnificently solved, it being possible to move consignments four hundred, even six hundred miles within a few hours.

The sea's contribution to the table is prolific. At the same time it is variable. This factor in itself conduces

towards pronounced wastage. We seem to have failed lamentably in our efforts to cope with the alternating spells of plenty and relative scarcity in a scientific manner. We have not mastered the adjustment of seasonal gluts, arising from the periodic massed movements of the fish, to shortages in order to maintain a steady and uniform supply the whole year round. In view of the immense strides which have been made in the art of preserving perishable foodstuffs, this deficiency is certainly somewhat remarkable.

The extremely low prices at which the bulk of the food from the sea, particularly of herring and sprat—occasionally mackerel—is available, are primarily responsible for the extravagance which rules. This state of affairs offers another interesting illustration of the fact that extremely cheap living promotes waste. We need only to recall the experience of the war to assure ourselves upon this point. Under the system of price control, coupled with abnormally high rates, fish purchases had to be conducted by the trade with extreme caution to obviate financial losses, while, similarly, the consumer was compelled to be more economic and less fastidious in his, or her, tastes. Under such conditions far less of the single fish was wasted, while greater ingenuity was exercised in the preparation of the less attractive edible portions for the table.

Nevertheless, no matter how extreme the care or economy manifested, a certain degree of wastage is unavoidable. For the most part the offal, which in itself is appreciable in volume, is regarded as irreclaimable and valueless except as a fertilizer. But this reasoning is fallacious. Fish-waste is capable of furnishing raw material in several forms to feed other industries. As yet this notable circumstance has not become fully appreciated in these islands, the practicability of using such refuse only having been established during the past few years.

Ability to turn fish offal to distinct profitable advantage not only solves the problem in its economic aspect, but at the same time indicates a promising outlook for glut catches and to which the ordinary markets are often denied. In this country the conventional disposal of surplus fish is decidedly deplorable for the reason that it follows the line of least resistance. A glut or late catch is generally sold at an absurd price in bulk to serve merely as manure.

If the fish could be turned directly into the soil such a use might not be exposed to severe condemnation, although it is to be deprecated because it represents a serious misuse of valuable food. But, as a rule, this cannot be conducted with the essential promptitude for obvious reasons. Then the farmer suffers a heavy loss. Vigilant gulls and other birds having a well-defined penchant for fish diet raid the land to enjoy a Gargantuan feast with the minimum of effort on their part. The birds will even follow a train, or road wagons, bearing a manurial consignment of their food, for miles from the point of landing and then, after it has been dumped, will swoop down to gorge themselves to the full. In many instances a farmer has been known to lose at least 50 per cent. of his purchase in this manner. He may essay alert and effective measures to combat the birds' attacks, but he will find it an unequal contest. In one instance, which came before my notice, the insatiable birds, catching sight of one or two open trucks laden with a freshly-landed catch *en route* to the land, attacked the wagons so vigorously as to cause a very perceptible shrinkage in the load before it reached its destination. Another farmer, who had been persuaded to buy two or three truck-loads of freshly-landed fish just because it was cheap, subsequently expressed his doubt as to whether he had driven a good bargain after all. The birds attacked the field over which the loads were distributed in such overwhelming numbers as to prompt the opinion that the field really contained more gulls than fish! So, after all, it is extremely questionable whether the purchase of a bumper catch for use as a fertilizer is really such a bargain as it may appear from a cursory reflection.

In our large cities and towns the treatment of fish offal and surplus supplies drawn from the markets, stores, and retail shops, as well as the hotels, restaurants, and clubs, for industrial exploitation, should present no difficulty whatever. It is an offal apart and a noisome one. Its susceptibility to rapid decomposition and the emission of obnoxious odours during the process demand its prompt removal. It cannot be handled with other refuse owing to its offensiveness. Consequently the system of special collection by vehicles of the closed tank type has become the general practice. In this manner the disconcerting factor

pertaining to the utilization of organic waste—effective segregation at the source—is assured.

Although, so far as we are concerned, the record of practical achievements concerning the industrial utilization of fish-waste is slender, owing to the few firms having been persuaded to embrace this phase of trading, it is consoling to learn that we possess what may be described as the leading authorities competent to deal with this issue in all its varying aspects, and to be equipped with the best approved facilities for conducting this work along the latest and most promising lines. There is one firm in particular which has built up a unique reputation in this direction, having been responsible for the design and construction, as well as installation, of the largest fish-waste reclamation plants in operation throughout the world. Some of these equipments are most elaborate in character, and their very dimensions, activity, scale of operations and prosperity, serve to demonstrate, in the most convincing manner, the enormous wealth capable of being won from fish scrap when the task is conducted along the lines advanced by scientific development. The British firm in question, to whose apparatus I have devoted extensive description in a previous chapter, has been responsible for the complete installations forming part and parcel of the huge canneries scattered along the western seaboard of the North American continent.

It somewhat redeems our own short-sightedness and lack of enterprise to know that we have a firm in our midst which has achieved many distinct triumphs in the great issue of waste reclamation. It retains an imposing staff of highly-trained chemists who have become specialists in this privileged province, and they have devoted especial attention to the exploitation of fish-scrap in the anticipation that this may yet develop into a pretentious British industry. The presiding genius of this organization has also associated himself intimately with the problem from the severely scientific side, as well as becoming thoroughly familiarized with the latest methods as practised in Germany, Scandinavia, and other countries in order to reap full advantage from the lessons which they are able to extend in point of equipment and practice. In the opinion of this active-minded and enterprising authority we have nothing to learn from the foreigner either in point of processes, plant, or efficiency.

We merely lack the necessary imagination, initiative, and commercial acumen to be able to reap the full financial and trading harvest to be gathered from the exploitation of fish-scrap. While we are apathetic and backward in this connection our Dominions are alert and astute. We need only to turn to the extensive installation recently laid down in Australia—a model of its type—and which was completed by the firm in question, to grasp what can be accomplished in this peculiar field.

It was extremely fortunate for us, as a nation, to be possessed of the knowledge and creative resources of a progressive firm. During the war, when the economic conditions became so tense, the question of the economic disposal of fish-waste to full commercial advantage suddenly assumed an unexpected significance. Specific raw materials were urgently demanded, and it was decided to search sedulously for additional domestic sources of supply. In the conduct of these investigations the potentialities of fish-scrap were forced to the forefront. The enemy was exploiting this field to its absolute limits, so why should we continue to ignore it? Cognizant of the precise possibilities of this industry and the financial attractions which it possessed the head of the firm of which I have written expressed his readiness to extend all assistance in his power. His knowledge of the craft, together with that of what the enemy could and could not do, proved invaluable, and enabled us to place the recovery of the wealth from this waste upon a solid foundation, and in such a manner as to allow of its indefinite expansion in the future.

So far as turning fish-scrap to commercial account has been concerned in these islands the axiom pertaining to the prophet and his own country has not been wholly applicable. The Germans endeavoured to establish an industry upon this raw material among us but signally failed. One or two small plants were laid down along the broad lines in vogue upon the other side of the North Sea, but they fell so far short of expectations or requirements, and were so strikingly inferior to British thought as to fall into disuse. They have long since been broken up.

The Teuton, however, was not solicitous of the welfare of the British nation in exploiting British fish-waste. He was merely prompted to plant himself here because the

necessary refuse—raw material from his point of view—was obtainable in such huge quantities and at a low figure. The output was shipped to Germany, where it commanded an attractive price and was in keen demand. The spurned and rejected of Britain became the highly prized of Germany.

Fish-waste falls into two broad classes, which are yet somewhat sharply defined. These are white fish and oily offal respectively, the herring being the best example of the latter category. Consequently, to conduct fish-waste reclamation and exploitation for the by-products upon a sufficiently comprehensive scale in these islands it would be necessary to separate the offal into the two distinctive classifications at the source. However, this would not be such a perplexing problem as it might appear at first sight. Such segregation is imperative for specific technical reasons, while one must also remember that the salt content of the offal varies widely in the two classes of fish.

Scrap of this character can be induced to yield three commercial products as a result of inexpensive treatment. They are respectively meal for poultry and cattle, oil, and fertilizer. A fourth commodity might be included, namely, fish-glue. Hitherto we have been content to draw upon other countries for our supplies of this article, although abundant raw material for its production has always been readily obtainable. But manufacture was doubtless regarded as being extremely speculative for the simple reason that the demand for this article was severely limited. For some reason or other fish-glue, though extensively used by the peoples of other nations, has never been regarded with pronounced favour in British circles although it cannot be excelled as an adhesive. Probably its peculiarly pungent odour has been responsible for our indifferent appreciation of its virtues. One or two small factories were equipped to conduct domestic manufacture, but they were far from being pretentious in their scale of operation.

Fish-glue has attained its greatest vogue in Germany, Scandinavia, Canada, and the United States of America—the last-named more particularly. Yet there is no reason why it should not become equally popular here. All that is required is to enlighten the community concerning its properties, and here is a grand opportunity for propaganda in support of a new industry. There is no secret associated

with its production as might possibly be imagined. The quality most essential to secure its widespread appreciation is merely a display of grim energy, push, and go. It is not a case of being called upon to advance the claims of an entirely new product. It is known more or less throughout the country from the circumstance that it is being exploited in varying degree throughout the world. In these circumstances the manufacture of British fish-glue from British fish-waste presents enormous possibilities, capable of illimitable development.

There are signs that we are bestirring ourselves in this direction. Heretofore fish-glue has always been made from the skins of white fish. It has now been suggested that, in this country, the bones might be put to similar account, the gummy content thereof being quite pronounced. Expert opinion favours the contention that such might be carried out to advantage, but there is one supreme difficulty—the adequate supply of the essential bones. They could be drawn from the filleting trade, but the extent of this supply is somewhat problematical. Fish-bones as such have not yet attained the high estate of recognition as a distinct article of commerce. Nevertheless a possible way out of this difficulty has been suggested. It should be quite practicable, when employing the oil extraction process to which I refer later, to sift out the larger bones before submitting the dry residue to the grinding process. In this way it would be possible to secure a ready supply of the necessary raw material for the production of the glue.

It has also been suggested in certain home circles that herring offal might be treated in such a way as to yield fish-glue, but this represents a venture upon untrodden ground. From such a statement it must not be inferred that this residue could not be induced to yield the substance desired, but so far as is known the offal has never been devoted to this purpose. Nevertheless, the suggestion is to be applauded. It is indicative of the new spirit attending the disposal of fish offal and goes to prove that British commercial pioneering is far from being numbered among the lost arts. The mere launch of the inquiry has sufficed to spur the chemist to investigate the problem, and any success achieved in the laboratory in this direction will

represent an enormous progressive stride owing to the magnitude of our herring fishery.

At the moment it is the recovery of the oil, meal, and fertilizer which constitutes the primary objectives of the industry. Of the three possible by-products the meal is doubtless the most remunerative. To a certain degree the contemporary concentration of effort upon the conversion of the offal into meal is due to the fact that this constituted the essence of German endeavour in these islands before the war. This meal was in keen demand in Germany, and the bulk thereof was dispatched to that country and Japan. The interruption of this supply to the former, as a result of the outbreak of hostilities, hit the enemy somewhat severely. Not only was he thus deprived of the crude meal prepared in Britain, but he was also denied the opportunity to turn the waste accruing from the consumption in the Fatherland of the heavy imports of British herring which were also summarily cut off. Doubtless Germany cherishes hopes that her industrious sons, who specialized in this distinctive craft, will be permitted to return to the scene of their former labours and to exploit British fish-scrap once again to the advantage of the German nation upon the conclusion of peace. May the wish become no more than father to the thought. We have not failed to profit from the many lessons taught by the war: we have been forced to recognize the many virtues of fish-meal and have made, and still are making, spirited efforts to repair the losses in this line of trading which, from our indifference and lack of imagination, we lost.

To galvanize British effort the fish-meal and fish-manure (guano) manufacturers have joined hands. Propaganda has been waged vigorously by the association, while agricultural societies and colleges have willingly co-operated to spread the gospel of enlightenment. Farmers have been canvassed sedulously, and the value of these by-products for feeding stock and soil have been brought convincingly before them. As a poultry food fish-meal is declared to be unsurpassable, and this circumstance has been driven well home. The result of this onslaught has been to force the farmer, an admittedly difficult individual to convince, into the admission that these products are possessed of far-reaching potentialities, the result being that, to-day, an increasing demand

for fish-meal and guano prevails, which has exercised the obvious effect of stimulating the exploitation of fish-scrap to a very pronounced degree.

During the war circumstances militated against the fulfilment of any impressive programme of development along modern lines. Plant and machinery could not be procured owing to the prior claims advanced by other industries. Consequently the problem became resolved rather into the modernization and adaptation of existing plants, many of which suffered from being woefully inefficient. But even in this direction much was achieved which cannot fail to be of distinct value, since it has served to illustrate what can be done in this field to financial profit. Now that trade is returning to the normal we may safely anticipate a striking advance along the whole industrial line in the installation of comprehensive plants coinciding with the very latest expressions of scientific thought, and which will not fail to conduce to the winning of impressively additional wealth from this hitherto sadly-neglected material.

So far as the white fish is concerned the conversion of the offal into meal represents a straightforward operation. It is merely dried under vacuum along the lines already described, a steam-jacketed drier or concentrator being used for the purpose. If the waste be stale or heavily impregnated with salt it cannot be used as food, the product in this instance being bagged for sale as a fertilizer. But the manufacturer, owing to the enhanced profit to be derived from the sale of the product in the feeding-meal form naturally strives to secure this article, and so, if designed for this use, the meal, after issuance from the drier, is passed through a disintegrator and is then graded through a sifting reel.

It is the exploitation of the herring and the sprat, both in the form of offal, glut catches, and condemned consignments, which presents the most attractive future in these islands. When it is remembered that the annual yield of the sea to the fishermen of Britain represents a round 4,000,000,000 herrings, it will be conceded that here must be a Klondyke of waste. Unfortunately, however, the issue is not so straightforward as it would seem to be. An enormous quantity of the catches are set aside for salting and curing to allow of export to foreign markets. In the

past Russia and Germany were our largest customers for this foodstuff, their combined purchases running to a round 800,000,000 lb. and exceeding £4,000,000—$20,000,000—in value. When the fish is salted the treatment of the offal presents a rather teasing problem. Its excessive salt content reacts against its conversion into poultry-meal except in very small quantities which are almost too insignificant to demand attention. When a fish-meal carries salt in excess of 5 per cent. it can be used as a constituent of blended or compounded foods, and then only sparingly. Consequently the possible consumption in this field can only be relatively trifling.

By salting the herring the saline content is increased to 20 or even 25 per cent., and the removal of the added salt offers a supreme obstacle. Fortunately it crops up only at certain seasons, but, at these periods, the quantities of offal and scrap to be treated assume imposing dimensions. As may be imagined, from what has been related, salt is the bugbear to the meal manufacturer and he is hard put to it to bring the figure down to one coinciding with trading requirements. What he desires is a simple, inexpensive process whereby the excessive salt may be eliminated without impairing the other virtues of the material in any way. Needless to say the discovery of such a preliminary treatment, meeting with his desires, will be received with unfeigned delight.

The suggestion has been advanced that the extraneous, or added, salt might be removed by subjecting the offal to a washing process. Undoubtedly, in this way, the desired end could be consummated to a certain degree, but, at the same time, there is the danger that the water would not only carry away the salt but would bear with it an appreciable proportion of the valuable nitrogenous matter which it is imperative should be retained. Unfortunately the salt is not completely free; it permeates the fish through and through and is held by the tissues. In view of the difficulty obtaining the manufacturer, as a rule, converts the heavily salted offal into fertilizer, but the enhanced salt content of the manure is regarded with certain misgivings even by the farmer.

This problem assumed its maximum intensity during the war. Huge quantities of barrelled herrings, destined

for export to the countries upon the other side of the North Sea, were held up by the authorities, who feared that they might ultimately find their way into enemy countries. As there was no other outlet for this produce, the salted herrings not being regarded with favour here, these prohibited exports were ultimately thrown upon the hands of the meal manufacturers. Such an instance is decidedly abnormal, but as already mentioned the issue arises to a lesser degree under conditions of ordinary trading, and, consequently, demands a certain amount of attention.

The engineering firm specializing in plants for the exploitation of fish-scrap, to which I have alluded, is attacking this problem in its extensive well-equipped laboratories. The chemist favours the theory that the extraneous salt is capable of ready removal. He also realizes that the perfection of a simple and cheap process to this end will probably accomplish a further beneficial purpose. Traces of blood are occasionally encountered in the offal, and their presence tends to discolour the resultant meal. These might possibly be eliminated contemporaneously with the removal of the added salt.

While I have dealt somewhat at length with the artificial salt problem, as it were, it must not be imagined that it constitutes a constant or inseparable feature of the fish-waste by-product recovery industry: far from it. Herring offal, while extremely varied, falls into certain distinctive classes. There is the scrap, or waste, as well as condemned consignments and surplus incidental to the fresh fish trade, which during the recurring periods undoubtedly touches a very high figure. Then there is the kippering and curer offal, the yield of which is much more formidable and easily recoverable from accumulations at central plants where such work is carried out upon a large scale. The kippering refuse, of course, represents that incurred in the process of kippering the herring and, comprising for the most part the gut of the fish, presents a material having little body or substance.

This waste is difficult to treat except along the most modern lines. For this reason, in pre-war days it was exploited only to a limited degree. Yet its accumulation was enormous. At some plants the piles of such refuse, which were to be seen, contained several hundred tons.

It failed to arouse earnest attention until the famine in oil burst upon us during hostilities. Then these dumps created interest because it was realized that such residue is rich in oil, enormous quantities of which were lying dormant. Forthwith plants were erected and equipped with the very latest types of machinery, which augurs well for the continuation of this manifestation of industrial enterprise in the future, owing to the great possibilities attending such reclamation.

Curer offal presents the heads and other waste portions as well as a material quantity of broken fish. This refuse has far more body, and so can be more readily treated to allow the valuable by-products to be recovered.

While we undoubtedly lagged behind our competitors in turning fish-scrap to commercial account it must not be imagined that we completely ignored this potential source of wealth. Nevertheless, for the most part, we were content to conduct operations along obsolete, inefficient lines, obtaining a return far below what might have been recorded. Had these plants been of modern design and equipment fish-waste reclamation would have advanced by leaps and bounds during the war period. As new machinery could not be obtained the main task was to adapt the existing plant to satisfy the demands of the authorities, which proved a task of distinct magnitude in itself, because the majority of the installations in operation possessed no striking feature other than that of being extremely wasteful from every point of view, offering, in fact, the most convincing illustrations of How *not* to do it!

In some works the practice was to cook the offal in steam-jacketed cookers. Now, when kippering offal, for instance, is being treated, the material, owing to lack of body, tends to coagulate at a certain stage in the process, a large volume of oil being liberated. This oil was skimmed and the residue, resembling a stiff mud, was removed to be wrapped in cloths for submission to extreme pressure in hydraulic presses. This action served to express a certain proportion of the oil remaining in the sludge. The compressed cakes were then transferred to a steam-jacketed drier to be reduced to meal.

This process, which has not yet been completely superseded, suffers from being involved and prolonged, although

these do not constitute the most adverse features. The greatest objections to it are the retention of an appreciable quantity of oil in the residue, even after subjection to pressure, which accordingly becomes associated with the meal. The last-named being sold for fertilizing purposes, the presence of the oil is objectionable, while the product also suffers from being low in ammonia. Furthermore, while the sludge is being pressed a pronounced volume of watery liquid is driven out to be lost down the drains. Seeing that this liquid carries valuable manurial constituents its loss is greatly to be deplored, and materially lowers the fertilizing—and financial—value of the meal.

A variation of the foregoing process is made in other works, but it only tends towards greater inefficiency and heavier losses. In this case only the oil resulting from treatment of the material in the hydraulic press is recovered! A third system involves the passage of the pressed cakes through a continuous direct fire-heated drier. This method is particularly objectionable, not only from the offensive odours which are thrown off, but because the ammonia content of the waste undergoes serious depreciation, owing to the high temperature employed. In certain instances the herring offal is even charged into the apparatus without any attempt having been made to separate the oil! Such a system, as will readily be recognized, has nothing whatever to recommend it.

It is the observance of such indifferent and unscientific methods as the foregoing which has been responsible for the commercial possibilities of fish-scrap to be belittled. The oil is undoubtedly ignored intentionally because fish oils are generally held to be worthy of inclusion only among the lowest grades of industrial oils. Nevertheless, were a chemist to be attached to such wasteful plants much needed reforms could be promptly introduced, although it is highly probable that the plants would be scrapped instantly at his instigation because of their lamentable inefficiency.

But we need labour no longer in ignorance. Modern science, as represented by chemistry and engineering, is able to offer an equipment capable of extracting the whole of the oil content down to 1 per cent. In other words, 99 per cent. of the oil contained in the raw offal and scrap can be recovered both cheaply and easily. The loss

of such a minute fraction as 1 per cent. undoubtedly represents a remarkable chemico-mechanical achievement.

The new process completely coincides with the dictates of contemporary science. The fundamental features are cooking the refuse under vacuum and the ultimate extraction of the oil by the aid of a suitable solvent such as benzine or other equally volatile spirit, or the benzine extraction system may be used from the very beginning, in a single and complete process. I have described this highly ingenious system in a previous chapter together with the system of operation followed. Obviously while the highest efficiency can only be derived from the installation of the complete plant, the processes being interrelated, the designer found it possible to modernize some of the old-fashioned and wasteful equipments to a very striking degree by the introduction of certain features to meet the exigencies of the moment.

A very convincing illustration of what can be achieved in this connection may be related. A firm specializing in the exploitation of herring offal desired to extend its plant, but was baulked in its intentions owing to the various restrictions which were in force. Accordingly it was compelled to consider the situation of how to derive more from the existing facilities without adding to them, at least only to an insignificant degree. At first sight this may seem to have presented a somewhat intricate, if not actually impossible, undertaking. Yet it was effected.

The modified arrangement introduced is decidedly interesting. The offal is cooked in the steam-jacketed cooker, as much as possible of the oil being skimmed from the mixture at the critical stage of coagulation. The sediment, or mud-like residue, is then transferred to an extractor where the remaining oil is recovered. This converts the residue into a still stiffer substance to be finished off in the ordinary steam-jacketed drier, instead of being completely dried in the extractor as originally designed.

This solution has proved to be exceedingly simple and eminently efficient. Although considerable handling is involved the extracting capacity of the plant has been nearly doubled. The advantages to be recorded are :—

(1) Ability to handle very much larger charges of waste when not reducing the material to a dry meal;

(2) Reduction of the raw material to the extent of the oil removed from the cookers;

(3) Reduction of the time required for the oil extraction by approximately 50 per cent.

Consequently, although the adapted, or modified, process entails the employment of extra labour, a result entirely due in this instance to the disposition of the plant in the works, the firm in question is able to obtain the value of the oil which would otherwise be lost, and which more than offsets the cost of the extra labour involved.

As a result of this development a review of the whole problem associated with the recovery of the by-products from fish-scrap was made. Cooking plant is not so expensive as extraction equipment. The question arose as to whether, or not, it would be possible, by the introduction of suitable automatic handling and other labour-saving devices, to obtain highly satisfactory results and efficiency from a combined plant. If this could be done then it would be comparatively easy and inexpensive to bring many of the existing recovery plants up to date to the advantage of the firms concerned. But the factor of capital outlay demands careful consideration, more especially in all matters pertaining to the utilization of waste products, because costs must be forced down to the irreducible minimum to show the necessary return to render them attractive. The result of close investigation of the issue led to the ultimate conclusion that the cost involved in connection with the cookers, extraction plant, and driers, in all probability, would be heavier than that incidental to the laying down of a straightforward extraction plant, pure and simple, to deal with the raw material and to turn it out as a dry product in one operation. One admitted advantage accrues from subjecting the material to preliminary cooking in steam-jacketed cookers. The oil thus obtained is somewhat better in quality than that derived by recourse to the solvent.

The modified or combined process above described enables one distinct end to be achieved. The objectionable and wasteful, as well as expensive pressing plant can be dispensed with. It also enables the ammonia content of the finished meal to be improved very noticeably, as the

following analyses of typical meals produced by the respective processes prove somewhat conclusively.

	Phosphates. Per cent.	Ammonia. Per cent.
Pressing process	6·5	7·5
Combined process	9·5	10·5

From the foregoing it will be seen that the enhanced yield of phosphates and ammonia fully justifies the additional expenditure incurred in regard to the plant and labour in connection with the extraction process, quite apart from the main duty of the plant. This is to extract all the oil, multiplying the usual yield many times over. Moreover, the quality of the oil-free meal obviously is superior.

With herring offal the extraction process by benzine ensures nothing being removed except the moisture and the oil. None of the liquor with its valuable ammonia is lost. Consequently the whole of the nitrogenous matter is combined with the resultant fertilizing meal.

To indicate the advantage of the benzine extraction process over the old-fashioned method of cooking, pressing, and subsequently drying the pressed cakes the accompanying analyses may prove informative. They refer to herring-mixed meal produced from kippering offal and damaged herring respectively.

Benzine Extraction Process.

	Per cent.
Ammonia	11·79
Tribasic phosphate of lime	9·66
Oil..	1·10

Old Process.

	Per cent.
Ammonia	7·5
Tribasic phosphate of lime	6·5
Oil..	15·5

Both essential fertilizing constituents are lower by the second than by the first process. This is not surprising in view of the fact that the subjection of the sludge to pressure drives off the watery liquor which is allowed to escape into the drains, notwithstanding that it carries a pronounced proportion of the ammonia and phosphate. Then it will

be seen that the benzine process yields a manure carrying a less proportion of the oil which the farmer regards with misgiving, because the oil has been recovered for sale as such. In other words it will be seen that, under the old process, 14·4 per cent. of oil is allowed to pass to the land where it is not required, instead of to industry where it is in keen request. At the prices which prevailed during the war this represented a wastage of £7—$35—per ton of fertilizer.

Under the extraction or solvent process the meal is turned out in a perfectly dry condition, either for use as a poultry food or fertilizer, the recovery of the oil and drying being completed in the one operation. The method is not only the acme of simplicity but it assures the maximum yield of oil, only 1 per cent. being lost. It is also rapid, it being possible to treat a charge of 8 tons of offal in 10 to 12 hours in one unit.

White fish and general offal do not contain sufficient oil to warrant the expense of solvent extraction. If it should be desired to secure 99 per cent. of the slight proportion the offal carries then submission to the benzine process is imperative, for the simple reason that it cannot possibly be recovered in any other way. The modern system of drying such offal is by steam heat under vacuum or reduced pressure.

This process, to which I have also devoted adequate attention previously, not only enables a product of high quality to be obtained, enabling it to command an enhanced price in the market, but it also conduces towards the retention of the nitrogenous contents of the meal. From the fertilizing point of view this is the main end to be achieved. Colour of the meal is another factor which demands recognition. It plays a far more prominent part in the commercial value of the product than might possibly be conceived. The American drying system, operating along direct fire-heated lines, while efficient so far as it goes, namely, the elimination of the moisture, yields a darker coloured meal, owing to the high temperature which has to be used, while, of course, the nitrogen content is lowered by such practice.

The vacuum system has also proved highly efficient for the production of cod-liver oil. The temperature of

rendering being low gives an oil of superior colour and odour, two factors of vital importance when the oil is being extracted for medicinal purposes. This is a somewhat delicate product to manufacture, especially when the livers are in a state of partial decomposition, because in this instance colour and sweet taste are particularly vital and difficult to assure.

I have referred to the circumstance that fish oils commercially rule low in the scale of industrial oils. But even fish oils possess one feature common to the highest grades of oils. They carry a certain proportion of glycerine. During the war the oil extracted from fish-scrap and offal was subjected to further treatment to swell our domestic supplies of this indispensable commodity. Even under normal conditions the reclamation of oil from fish waste to secure this glycerine offers further inducement to this phase of industry, and is also capable of considerable development.

Fish oils are also destined to play a more prominent part upon the table than has been the case heretofore. Their inherent fluidity and refusal to solidify, except at low temperatures, have hitherto reacted against their use in this direction. But the increasing demand for margarine as a substitute for butter, and the discovery of the hydrogenating process for eliminating the two outstanding defects, have invested the future for fish oils with additional significance, more especially as by the hardening process, as it is called, the pungent taste and aroma so distinctively of the sea and its inhabitants are removed. By virtue of this discovery fish oils are entering more and more extensively into the manufacture of margarine. The circumstance that they yield a product so closely allied to the genuine article from the dairy as to be difficult of detection, except by elaborate investigation and specialized methods, has served to accentuate this tendency.

We must derive far-reaching benefits from the utilization of our fish waste of every description—not only the offal arising from the preparation of the foodstuff for the table either in a fresh, kippered, cured, or canned condition, but the inedible contributions from the trawls. Those members of the sea's vast and varied population, such as the whale, which are trapped for certain highly-prized portions of their bodies, must be fully exploited. For decades the whale

fishery has been conducted along the most wickedly wasteful lines for which we are paying to-day. The Scandinavian whalers have been among the worst offenders in this respect, but they are now being compelled to turn from the folly of their ways and are endeavouring to utilize the whole of the carcases of their prizes.

So far as the average member of the community in these islands is concerned it is a moot point whether he, or she, has any tangible idea of the magnitude of the British sea-fishing industry. From the abundance and cheapness of the food a vague notion obtains that it must certainly be somewhat impressive. To obtain a graphic idea of its enormous proportions we must venture beyond the limits of domestic consumption and see how we help to feed the foreigner. Under normal conditions we ship approximately 1,250,000,000 lb. of fish every year, representing in value a round £7,750,000—$38,750,000. Of this huge total the humble herring represents nearly 1,120,000,000 lb., valued at approximately £6,000,000—$30,000,000. Of the total herring catch about one thousand million—1,000,000,000—lb. are subjected to curing or salting for the foreign markets, the value of those exports being £5,350,000—$26,750,000—so that the herring may truly be said to form the backbone of the British sea-fisheries. In these circumstances, and bearing in mind the huge quantities handled, the item of waste must necessarily loom heavy. It cannot be avoided. Therefore it behoves us to turn our harvest from the sea to the utmost advantage and to eliminate the item "loss" from our operations.

As the by-products from fish-waste become appreciated we may even proceed to the lengths pursued along the northern Atlantic seaboard of the United States. There the harvest of the menhaden, a fish totally unfit for human consumption, is carried out expressly for the oil obtainable therefrom. It has become a flourishing trade—one which is steadily expanding—special vessels being engaged in the fishery. While it is questionable if much fish of a comparative character and totally unsuited to the table is to be caught in the waters around our coasts, Farther Britain can point to a different state of things. Our Dominions should find it profitable to emulate the American example and exploit adjacent waters essentially for inedible fish to

extract the oil and to convert the residue either into fertilizer or poultry food. There is a lucrative and developing market for all three commodities.

But the problem of to-day, in so far as it particularly affects Great Britain, is to solve the issue incidental to the glut catches, so as to prevent the wasteful distribution of the raw fish over the land as the easiest way out of a perplexing dilemma. If we can divert such unwanted hauls from the sea to reclamation factories, confident in the knowledge that there they will be worked up to their utmost in the interests of commerce, we shall be able to record an industrial and economic achievement of incalculable consequence to ourselves. To dump newly-caught fish upon the land merely because it cannot be absorbed by the community as a foodstuff constitutes one of the most deplorably wasteful, if not actually criminally extravagant, charges ever levelled against contemporary civilization.

CHAPTER VII

WINNING WEALTH FROM SLAUGHTER-HOUSE OFFAL, CONDEMNED MEAT BONES, AND BLOOD

UNDOUBTEDLY one of the wonders of civilization is the ability to preserve and transport such a readily perishable foodstuff as meat in a chilled and frozen condition for an indefinite period of time. By this means cattle roaming the extensive ranches of North and South America, Australia and New Zealand, are rendered available in a fresh form for presentation upon the tables of Britain to supplement the severely limited domestic supplies. During recent years the growth of this traffic has been remarkable, and it will not be long before we touch the million-tons-a-year mark for imported beef, mutton, pork, exclusive of ham and bacon.

Yet the development of this trade has reacted directly against our own interests. The dispatch of the carcases to these islands in the dressed condition has deprived, and still is depriving us, of much valuable raw material to which we should have access were we to raise sufficient meat to satisfy our own needs. This is the exploitation of the offal or inedible portions of the beast, the products obtained from which are not only of marked intrinsic value, but enter into so many other and varied industries. From this statement it must not be imagined that we are entirely prevented from establishing a meat-waste industry, since our domestic killing trade is of distinct significance and is supplemented to a certain degree by the "home-killed" business. The latter, as is well known, represents the shipment of cattle to this country in the live condition to be slaughtered upon landing.

In these circumstances it would be perfectly feasible

for us to establish the meat residue exploitation industry upon a comprehensive scale but for the fact that existing conditions are decisively adverse, although we could scarcely aspire to attain the magnitude and operations of the huge meat-packing plants of Chicago. It is extremely doubtful if we really appreciate the possibilities of this business, and, because of our ignorance, we, as a nation, are the losers. We have permitted the local or territorial slaughter of cattle to be carried to an extreme length. The municipal abattoir constitutes the feature of the slaughtering trade of these islands, and although this practice was introduced to overcome the shortcomings of the private slaughter-house, which were many, and to ensure killing and dressing animals under the most hygienic and scientific conditions, yet it is a matter for serious consideration as to whether the municipal practice should not be superseded by a centralized system, acting under State or private control, the latter for preference, so as to give full rein to the display of initiative.

There is no logical reason why the slaughter of domestic cattle should not be conducted at a central point. Such a plant conducted along the lines practised at Chicago would be of far-reaching benefit to the community. Supervision would be more effective, simpler and less expensive, inasmuch as it would be possible to dispense with the multiplicity of officials now obtaining—another form of waste. It would also enable the residues from the trade to be turned to utilitarian advantage along the most economic and profitable lines, owing to their very bulk. A visit to the Chicago stockyards brings home very forcibly the magnitude of this trade and the wealth to be won from the residues which accrue. It has been declared, and with considerable truth, that at the American stockyards the development of the by-products is every whit as extensive and as important as the preparation of the ostensible staple product. It is actually more profitable, and brings in as great if not greater revenue.

The arguments which would be levelled against the establishment of a central meat-packing plant in this country are many and obvious. In the first place full voice would be given to the apparent futility of sending a live animal from 20 to 600 or 700 miles merely to be killed, and to return the dressed carcase to be sold. Superficially it does appear

to be a senseless employment of transport and to incur needless expense. Yet such a practice is followed upon the North American continent. Animals are shipped alive over hundreds of miles to be killed and returned to the point where they were bought, in the form of dressed meat ready for consumption. But the argument is fatuous. Centralized slaughtering facilities secure equitable distribution, as well as prompt movement, since the trade is sufficiently heavy to demand the inauguration of a special handling and transportation system. Then again such a practice allows bulk shipment combined with long haulage, two essential conditions to economic transportation. If the method were practised in these islands, not only would it be possible to take full advantage of the latest manifestations of science in so far as it affected the industry, but it would enable the residues forthcoming in enormous quantities to be treated upon the spot in the reclamation plant forming an integral part of the stockyard equipment. The revenue derived from the disposal of the by-products rendered available in a commercial form would not only more than offset the charges incurred concerning transportation, but would tend towards the primary product—the meat—being sold at a lower figure to the public.

Under the present system of local killing much of the offal escapes reclamatory treatment for the simple reason that the quantity forthcoming is so limited as not to be deemed worthy of exploitation, or else is subjected to obsolete or inefficient by-product recovery methods. In many instances it is sold to a contractor who endeavours to conduct bulk treatment upon a reduced scale, paying a relatively low price for the refuse and one quite disproportionate to its true value. In some instances the contractor does not attempt to carry out by-product recovery, but merely acts as a middleman, dispatching the various residues to the quarters where he knows they will be taken in hand to be worked up.

During the past few years the science of winning wealth from slaughter-house offal of every description has made enormous strides, effort having been concentrated upon the recovery of the very utmost yield of by-products for the simple reason that the demand therefor is exceedingly keen, while prices are necessarily attractive. This applies particu-

larly to the fats, the value of which ranges up to as much as £50 per ton, according to grade, although other commodities simultaneously secured, such as meal for cattle-feeding and fertilizers, are able to command equally impressive prices. A graphic idea of the degree to which this science has been advanced is obvious from the dimensions, comprehensiveness and modernity of the by-product installations which have been laid down as adjuncts to the mammoth cattle-killing plants in various parts of the world, the majority of which, as I have pointed out in a previous chapter, are of British origin, design and construction, and many of which have been, and still are being, supplied from this country. Surely it is somewhat anomalous that other countries should come to us for the latest expressions of ingenuity and invention in this province when we are unable to point to a single pretentious plant in this country! At the same time it is distinctly gratifying to learn that if Britain cannot display sufficient imagination or commercial acumen to use plants of this character, she certainly can build them, and is not only able to keep well astride of the times, but is fertile in thought concerning a highly specialized ramification of industry.

As a matter of fact it may come somewhat of a surprise to learn that British thought is far in advance of American practise, as manifested by the stockyards at Chicago in regard to the utilization of appliances and process for the treatment of meat residues. The interests at the mammoth plant were approached with the latest British development in this line—the solvent extraction process described in a previous chapter—it being recognized that its introduction to the American stockyards would apply the seal of highest approval to the invention and represent a great achievement for the British interests which had evolved and perfected it. It possessed every virtue likely to make appeal, more particularly the means of enabling the American packers to add to their already huge profits. The process was investigated, and its superiority over the methods in vogue was frankly conceded. But the Chicago industry firmly declined to embrace the invention, not from feelings of hostility, but because the interests concerned had developed their own plant along lines, and to a degree which would not readily permit a revolution. To have introduced the

new idea would have been to disorganize the whole business of by-product reclamation and would have demanded the revision of methods, knowledge, practice, and routine. Questions of cost did not enter into the issue at all. The packers merely declined to disturb the system they had standardized and had carried to such a level of perfection.

But the packers were not wholly opposed to progress. Although not willing to introduce the system into their plants, they were quite ready to turn over their wastes, after they had extracted as much as they could of material value therefrom under their system, to the British interests. The inventors accepted the proposal, and to-day one may witness the strange and anomalous spectacle of British interests taking over the residues from residues from the packing plants for further treatment, and conducting the unusual method of trading to their financial profit. It was confidence in the superiority of the new idea which brought such signal success. Yet this exploitation of wastes from wastes is not peculiar to Chicago. It is even being practised to a limited degree in these islands, which suffices to prove that certain quarters are fully cognizant of the wealth awaiting to be won from waste, and that it pays to conduct the process to the recovery of the uttermost retrievable ounce even from such material.

Certain of our municipalities, fully alive to the value of the waste incidental to the operations of their abattoirs, are sparing no effort to utilize such material to the full. However, in many instances, their enterprise is thwarted by the circumstance that the butchers making avail of the Corporation facilities extended, possess certain vested interests which must be honoured. Accordingly it is not possible to conduct reclamation to such limits as would be attainable were methods comparable with those prevailing at the Chicago stockyards in operation. To be able to extract the utmost from the refuse it is imperative that the authorities should be given unrestricted control of the animal, preferably absolute ownership. This is the reason why the big private packing plants are able to achieve such eminent success. They purchase the live animals, and consequently are free to exploit them in accordance with the principles they have elaborated. Nevertheless, despite the difficulties

obtaining, much good work is being accomplished in British circles concerning abattoir waste exploitation.

The case of Edinburgh may be cited as an illustration. I purposely select the Scottish city for the reason that—so far as municipalities are concerned—it is possessed of one of the most up-to-date installations in the country, is enterprising, and serves to bring home how vested interests can mar a record of possible achievement by restrictive action. The blood is sold to a contractor, who, however, is compelled to sell back to the meat trade such quantities of this article as may be required. A proportion of the offal is also sold by the meat trade.

Diseased meat, condemned as unfit for human consumption, is treated by the authorities in the Scott plant which they have acquired. The waste is thoroughly sterilized by steam, the residuals, comprising non-edible tallow, meat fibre and bones being sold. The plant cost £600—$3,000. The working costs may be set down at approximately £200—$1,000—per annum, while the income from the sale of the uncertain quantities of meat of which disposal is made averages about £430—$2,150—per year. The hoofs and spurs of the feet of cattle, the parings of ox-feet, a small proportion of waste offal, and the manure originating in the slaughter-house, are sold by the Corporation. The sum derived from these sources during the 1917–18 financial year amounted to £533 5s.—$2,666.25—while the revenue from the sale of blood was £437 11s.—$2,187.75. All things considered it must be conceded that the by-products resulting from the operation of the slaughter-house by the Corporation of the Scottish city are fully utilized, although the defects arising from divided responsibility for the development and disposal of the wastes are obvious.

Divided interests exert another reactive influence. The public authorities are debarred from making full avail of the latest improvement in the art and craft of waste recovery. For instance, although the leading abattoirs of these islands have acquired reasonably up-to-date plants, they are all operated upon the open steam principle, with and without vacuum. The method, while satisfactory so far as it goes, does not offer the means of securing the utmost from the available material. But the authorities do not feel justified in going to the expense of acquiring the latest appliances

for the prosecution of the work of reclamation, an attitude which is perfectly explicable in the circumstances.

Of course, the community suffers, though imperceptibly. The plants in question allow a certain proportion of waste to be lost which in the course of the year represents an imposing figure. Furthermore, the whole, or the greater part, of the "stick liquor" or gelatinous liquid thrown off during the fat reclamation process is lost, being allowed to escape down the drains. The abandonment of the stick liquor is regrettable because it constitutes a waste capable of being treated with profit, as I explain later. But it is doubtful whether the average municipal plant, even if it had absolutely unfettered control of all the waste products arising from the slaughter of cattle for food, would be in the position to treat the stick liquor to commercial advantage. An evaporative plant would have to be incorporated to concentrate the gelatinous substance to the desired density, and only in a few instances would the quantity of material treated be adequate to render the utilization of the stick liquor profitable. But this constitutes an additional argument for centralized meat packing and offal exploitation in these islands.

Accordingly effort is exclusively confined to the recovery of the grease. I have described the outstanding features of the vacuum system in a previous chapter, to which I would refer the reader desiring enlightenment in connection therewith. The grease is drawn off by a special skimming device into a fat tank to be clarified. Then it is run into barrels or other suitable receptacles for transport. It is scarcely necessary to point out that the grease and tallow thus obtained from condemned meat and other offal, although thoroughly sterilized in the rendering process, are graded only as fit for the manufacture of soap and other articles of utility, as distinct from products of edible importance.

The term "offal" in its application to meat residues is somewhat ambiguous. It not only comprises material coinciding with the general interpretation of the term, but certain portions of the animal which are really suited to the preparation of foodstuffs for the table. Consequently all grease recovered from the digester is not necessarily adapted to manufacturing purposes only. In these circumstances it is necessary to grade the fat before treatment, the fresh fat, which is quite suitable for yielding material

adapted to the preparation of margarine, for instance, being kept distinct from the lower grades which cannot possibly be classed as edible. Selection and separation treatment of the two grades—edible and inedible—are profitable because, while both are in keen demand, it is the former which is able to command the higher market figure. But when edible fats are sought it is preferable to employ the steam-jacketed digester because the fat thus obtained, from the fact that the steam is not brought into contact with the material during the cooking process, is of enhanced quality, being sweeter, while all the natural properties of the fat are retained for reasons already set forth.

Although, therefore, the most popular system in vogue for reclaiming fat from slaughter-house residues is exposed to criticism, owing to what may be described as lack of efficiency in operation due to the recovery of the fat not being as high as it might be, it appears to meet the conditions of the average municipal abattoir. City and borough corporations, unlike private organizations, are not in the position to scrap an existing plant for one which is of later date and greater efficiency, because there is not the same incentive to reap the utmost benefits attainable as prevails under private conditions where the full brunt of competition is encountered. Of course, the initiative of corporations is just as pronounced as that of private firms and individuals, but it is the exception rather than the rule. Furthermore, the municipality is not in the position to run a plant under full load, or even at a uniform pressure the whole time. It is only able to handle the waste as it accumulates during its own abattoir operations. On the other hand, the private exploiter can acquire a plant of such capacity as to cope with the steady flow of material from the slaughter-houses, thereby keeping the by-product recovery installation working steadily at a point approaching its productive limits.

Nevertheless, the results achieved with the prevailing type of plant afford interesting reading, although it is somewhat misleading to cite them. The material varies so widely both in quantity and quality, while the ultimate fat-yield likewise fluctuates markedly. A fat bullock which has been condemned would naturally be expected to furnish a good contribution of fat. On the other hand, only a low percentage could reasonably be anticipated from a lean cow. In these

circumstances a comparison without full details concerning the material handled is difficult. The figures available may be set down as being representative, though they should be accepted as being typical rather than empirical.

A consignment of condemned meat, weighing 2,240 lb., was placed in the digester. The quantities of the respective materials recovered were :—

	Lb.		Per cent.
Tallow	336	or	15
Fibrine or meat-meal	392–428	or	17½–20
Bone-meal	280–336	or	12½–15

In another instance a somewhat heavier consignment of condemned meat was committed to the recovery plant. Its composition was :—

	Lb.
Beef	84,000
Pork	1,607
Mutton	818
Veal	354
Offal	20,370
Total	107,149

The tallow yield was 21,638 lb., or 20 per cent. of the total volume passed through the digester. Pronounced quantities of the fibrine and bone-meal were also secured. But the tallow yield alone should serve to convince even the most sceptical that it pays to submit condemned meat and slaughter-house refuse to a process of by-product recovery. It was not so many years ago that such valuable waste met with an untimely end—incineration in the destructor as the most effective and economical means for its disposal. Had this practice been followed in the instance under review the authorities would have allowed material worth, according to current market quotations, at least £500—$2,500—to vanish up the chimney in preference to the display of a little exertion and knowledge to secure what is in such wide and urgent request—the fat.

While the average organization, either municipal or private, conducts operations upon too limited a scale to deal with the gelatinous or "stick liquor," the large establish-

ments, on the other hand, are confronted with such immense quantities thereof as to render its further treatment justifiable and profitable. But the liquid is extremely thin or weak, that is low in the gelatinous constituent in its crude form, and so requires to be concentrated. To effect this at the lowest cost it should be passed through the Scott multiple effect vacuum evaporators. These are heated by the exhaust steam. In this form of evaporator the heating effect of the steam is multiplied in several stages, thus doing so many times more work for one supply of fuel as compared with a simple evaporator. The evaporation proceeds progressively and continuously, the liquor leaving the evaporator at a high degree of concentration owing to the water having been driven off. The gelatinous residue accruing from this treatment may be blended with the fibrine or meat-meal, thereby enhancing the value of the latter, which thus becomes enriched with ammonia and protein to an appreciable degree.

For some reason or other the treatment of the "stick liquor" has not aroused the measure of serious attention in these islands which it deserves. While, of course, greater results are attainable from treatment of the liquid upon a huge scale, yet relatively small quantities can be exploited very profitably, because the jelly finds an attractive market as crude tub size, the demand for which to-day is somewhat keen and firm. Doubtless hesitation to turn the stick liquor to economic account is due to lack of knowledge concerning the improvements in the rendering process, and the difficulty encountered in this direction in the past. Under the old system, where the practice was to evaporate these liquors in open vessels, the nuisance created constituted the insurmountable obstacle. The work could not be carried out without polluting the whole neighbourhood. With the Scott evaporator, however, no more nuisance is created in concentrating the offensive liquor than attends the exploitation of noisome fats by the patent digesting process, for the simple reasons that the work is conducted in closed vessels, and all obnoxious vapours thrown off during the treatment are led to the furnace to be consumed, escape of the free gases into the air being rendered totally impossible.

British waste exploiters are beginning to appreciate the advantages of the closed evaporative system, and in their determination to secure every retrievable ounce of com-

mercially valuable products from waste are now devoting greater attention to the stick liquor. The policy is one which cannot fail to pay so long as it is conducted along the correct lines such as I have indicated.

Before leaving the question of the stick liquor it is curious to remark how some firms, while complimenting themselves upon the assiduity and diligence with which they treat their wastes, are yet likely to allow a certain material, and one which is of distinct value to their own businesses, to slip through their fingers merely from lack of knowledge. The abandonment of the stick liquor arising from the digestive treatment of meat-waste represents an interesting example of such inadvertence.

Many manufacturers dealing with meat products have installed a fat-recovery system for the treatment of their waste upon the spot, the primary idea being to secure the good edible fat for re-use in connection with their own processes. Furthermore, from their association with the cooked-meat trade they find it necessary to absorb material quantities of gelatine to carry out the glazing work in the preparation of brawn, pies and other dainties. They purchase the crude gelatine for the purpose, submitting it to careful treatments to adapt it to their varying requirements. Yet, if they but knew it, they have no need to spend a single penny —or cent—upon gelatine wherewith to conduct the final appetizing touches to their wares. They have as much of this raw material as they can possibly require immediately to hand in the stick liquor, and which, in the majority of instances, they allow to escape.

As a matter of fact this liquid residue is far preferable to the commercial gelatine which they buy for glazing purposes. They need only to attach an evaporator to their recovery plant to bring about its concentration. But this is not the only advantage. The gelatine has to be of varying densities or strengths according to its precise application. When they have their own evaporator this desideratum is readily fulfilled. It is only necessary to draw off the material from the evaporators when it has reached the requisite degree of concentration for immediate use. Not only is appreciable time saved, but the up-to-date firms are better off in pocket because they are utilizing a waste for which otherwise they would have to employ a purchased commodity. Even

if they conduct concentration to the absolute it does not matter ; the article is then recovered in the form of an edible jelly. This can be clarified, if desired, to be sold as such, or it can be sold to fellow-manufacturers who do not happen to have such a plant. Failing such disposal there is no difficulty in selling the jellied mass as tub size.

In a previous chapter I have described the reclamation process practised by the military authorities in connection with bones arising from the cutting-up of meat for the army, as well as those recovered from the swill-tubs. As indicated, however, exploitation is conducted only to a certain point, when the bones are handed over to the degreasers. It is then that the true recovery of the commercial constituents of the bone commences. The bone is an invaluable friend to the human race as an article of commerce, though it is to be feared that what may be described as the "bone tree" is only imperfectly understood. Its far-reaching value as a fertilizer is certainly appreciated, but this really represents the final application of the article, and may be said to be the only remaining field of utility for the ultimate residue of a residue. Bones enter into a wide range of industrial and manufacturing operations. For this reason they should be carefully gathered and retained for surrender to recognized collecting mediums rather than suffer abandonment or destruction.

The housewife is prone to regard them as mere waste when she has extracted the utmost recoverable value therefrom in the kitchen. She may possibly retain them until the itinerant specialist in this commodity, to wit, the rag-and-bone man, comes round, in which event it is sure to be sped once more on a journey of industrial exploitation. But at least one-third of the bones which enter the households of Britain escape reclamation. They are wantonly wasted, and it is to be feared that the kitchen stove is mainly responsible for this loss. The volume of bones which should be forthcoming from domestic circles in Great Britain, were the dictates of thrift religiously followed, is scarcely appreciated, but it is estimated that the supply should be at least 100 tons per week from every million members of the population.

In these islands the bones are divided into two broad classes. The one division, comprising what is known as

"green" (raw) bones, represents those collected from butchers' shops, bacon-cutting works, and other similar sources. The second class, defined as "streeters," include those forthcoming from the recognized collectors of such waste, hotels, restaurants, clubs, and private houses, and are those which have been passed through one or more cooking processes.

In the case of green bones it is customary to digest them, when really fresh, with open steam to recover the edible fat. Shank and marrow bones, as distinct from rough bones, are also able to yield a certain proportion of edible fat, and after having been digested or boiled still retain a considerable percentage of grease which it pays to extract. Consequently these, together with a certain quantity of less fresh green bones, and the streeters, are then passed through the benzine extractor to be degreased down to 1 per cent.

The shank and marrow bones are sawn up, the centre sections being selected for the production of such useful articles as knife and fork handles, buttons, and other utilitarian commodities for which their composition renders them eminently suitable. The ends or knuckles are degreased by submission to the solvent extraction process, and then, in some works, are subjected to further chemical treatment, which is somewhat elaborate, to be converted into baking-powder.

Otherwise the bones, after being degreased, are passed through other processes for the extraction of their gelatinous constituent. This is secured in the form of a liquor which is evaporated in vacuo to a jelly. The last-named is cooled into cakes and then dried on nets, or, if preferred, the liquor may be dried direct into glue-powder. By following a more complicated process gelatine can also be prepared from the degreased bones. But the gelatine thus obtained does not compare in quality with that extracted from skins. The degelatinizing process is not always followed, for the reason that some makers prefer to produce the higher quality bone-meal which is procurable from non-degelatinized bone. Obviously, however, the more profitable and economic procedure is to pass the bones through an associated glue plant.

The ultimate residue, whether degelatinised or not,

is a bone-meal which constitutes the well-known fertilizer. The bone-meal, to be of the utmost feeding value to the soil, should carry little or no fat. At the same time, however, it should be rich in ammonia and phosphoric acid or superphosphate, which is determined in terms of tribasic phosphate of lime. To show how these requirements can be adequately fulfilled by submitting the raw waste to a complete recovery process, such as I have described, an analysis of a typical bone-meal produced from degreased bones—degreased by the benzine extraction process—but which have not been degelatinized, is given thus :—

	Per cent.
Tribasic phosphate of lime	46·60
Nitrogen, 6·07 per cent.=ammonia.. ..	7·37
Moisture	8·04
Fat	1

The high percentage of ammonia, namely 7·37 per cent., deserves especial notice inasmuch as it compares with a yield of 4·5 per cent., which is the average figure recorded with fertilizing meal obtained from steamed bones. It may possibly come as a surprise to many to learn that it is the proportion of the nitrogenous content, as represented by the ammonia, rather than the phosphoric acid content, which really determines the commercial value of this manure. The higher the figure to which the ammonia figure can be forced the more attractive the price which the fertilizer will command upon the market. Thus, under normal conditions, every 1 per cent. rise in the ammonia constituent will increase the price of the bone-meal by 14s.—$3.50. On the other hand, a 1 per cent. increase in the proportion of superphosphate only serves to increase the price of the meal by 11d. to 1s. 2d.—22 to 28 cents.

The grease obtainable from green bones varies somewhat. It is affected to a marked degree by the skill and care with which the butcher wields his knife. If the bone should be scraped very clean and carefully, naturally the bulk of the attached fat is removed. But an average collection of green bones will yield about 15 per cent., or 360 lb., of fat per ton of bones treated, while the dry bone-meal will range from 1,286 to 1,344 lb. Bones which have been collected from marine store dealers and rag-and-bone

merchants are not so liberal in fat yield. The repeated cooking to which they have been subjected in connection with the preparation of dishes for the table relieves them of approximately 5 per cent. of the fat which they originally carried, i.e. in the raw condition. Consequently, degreasing only enables about 10 per cent., or 250 lb., of fat to be recovered from every ton of bones treated. In this instance the bone-meal yield may be set down at 1,568 to 1,680 lb. per ton of bones. The grease remaining in the meal varies from 0·5 to 1 per cent.

As may logically be supposed, cattle-slaughtering for food produces large quantities of blood. This is an extremely valuable residue, and so is carefully collected in suitable vessels. It is then transferred to shallow receptacles and permitted to stand for a time. Blood is composed of two fundamental constituents—the serum and the clot respectively. The former, which is the albumen, is the glutinous-like, yellowish liquid which comes to the surface, the clot settling to form as it were a sediment. The serum is recovered by skimming with a suitable device, to be distributed in extremely thin layers, applied with a brush, to dry. Such a careful procedure is imperative owing to the difficulty of drying out albumen. When dry the blood-albumen is peeled in the form of thin flakes. Its applications are numerous, one of the most important being its employment for the clarification of sugar. The clot is likewise secured to be sent to the special plant, where it is also dried.

It is common knowledge that blood constitutes a magnificent fertilizer, and this is the purpose to which the dried clot is applied. In a well-designed vacuum drying plant, such as the Scott, which has been designed especially to treat such residue, the efficiency is high. The yield from the clot may be said to range from 25 to 30 per cent.—560 to 672 lb.—per ton of raw clot treated, and is recovered in the form of a rich red dry powder.

One great objection levelled against the recovery of the blood for fertilizing purposes has been the very offensive odour which is thrown off during the drying operation. But when the task is conducted under the vacuum system no such nuisance is created, because the obnoxious gases are led to the fire to suffer combustion. In dryers of the conventional type, in which the noxious gases are removed by

the aid of an exhausting fan, or suffer discharge into the chimney, the process does represent an intolerable nuisance to the neighbourhood, because there is nothing to prevent the pollution of the atmosphere. Furthermore, and this is the most important point to remember, by drying the blood under the vacuum system the ammonia content of the waste, which normally is high, can be preserved to the full, owing to the drying operation being carried out at a much lower temperature than is incidental to the usual practice.

Dried blood appeals to the farmer for the nourishment of his land essentially because of its pronounced proportion of nitrogen or ammonia. Consequently it is incumbent to keep this figure as high as possible and thus secure the advantages of market quotation. Naturally the percentage thereof in the resultant meal will vary strikingly according to the drying process practised. Ammonia is an exceedingly volatile ingredient, its tendency to escape being accentuated as the temperature employed is increased. It is only by keeping the heat factor at a low level consistent with the complete fulfilment of the desired operation, that the ammonia can be retained. Under the vacuum system this end is assured, owing to the low boiling-point due to the reduced pressure or vacuum. A typical analysis of vacuum-dried clot blood may be cited :—

	Per cent.
Moisture	9
Mineral matter	1·61
Nitrogen	14·02
↘=ammonia	17·02

In cases where the albumen is not required separately the whole blood is dried without being separated or "clotted."

It is obvious from what I have related, that the recovery of by-products from what has always been regarded as waste of a most repulsive character, that is from the popular point of view, can be turned to striking commercial and industrial account. Similarly it is only too apparent that such by-product reclamation as is possible demands a plant of the most complete description, to ensure all and every substance of utilitarian value being secured along the most efficient lines and to the uttermost ounce.

The day has gone when the crude methods which sufficed to satisfy individual or specific requirements should be continued. To endeavour to render it profitable to recover but one article out of many which are reclaimable simultaneously, and for the expenditure of only a little more effort, time and money, may be compared with mining for one hundred carat diamonds and allowing all those of lesser weight to fall back into the earth.

CHAPTER VIII

TURNING WASTES INTO PAPER

PAPER has been described as the World's Friend. Truly the application is apt, when we recall the varied, and, in some instances, almost incredible uses to which it is put, from carpets to boxes, wheels of infinite variety to artificial flowers, table linen to boards. Little wonder, therefore, that we have come to regard it as indispensable to our every-day social and industrial existence. Being cheap, abundant and easy to obtain, is it surprising that we became extravagant in its use? We scarcely ever hesitate to bestow even a passing thought as to where, and how, we get it. We talk glibly of "imported" without pausing a moment to reflect upon the real significance of the expression. It was not until war burst upon us to deliver its many disconcerting jolts that we came to our senses, and were then compelled to acknowledge that while paper may be a most tractable servant it is certainly a tyrannous master.

How many people would credit the statement that paper could exercise any influence upon the cost of living? Not one in a thousand it is safe to hazard. But let us reflect. In the days when paper or cardboard was forthcoming in plenty the tradesman never contemplated for a moment the suggestion that he should be sparing in his use of the commodity, or even saddle his customer with the cost of this indispensable wrapping material. What if a sheet of brown paper cost a farthing—half a cent—or paper bags could be secured for ten a penny (2 cents)? The expense was so trivial as to be insignificant. He could readily shoulder it without any financial detriment to himself. But when that sheet of paper cost approximately 1¾d.—3½ cents—or when the bag involved an outlay of 1½d.—3 cents—the

tradesman, turning over in his mind the huge quantities he would be compelled to provide during the business of the day, regarded the whole question in a different spirit. He declined to bear the burden, and so promptly passed it on to the customer.

To grasp the paper situation as it affects this island kingdom we must hark back to the glorious days preceding 1914. We made paper upon a relatively extensive scale in our own mills, and the industry flourished amazingly. But to what extent did indigenous materials enter into the composition of the article? Barely 10 per cent. We preferred to buy 90 per cent. of our raw materials from foreign mills brought into existence for this especial purpose, and, be it remarked *en passant*, the foreigner found it highly lucrative to trade upon our disinclination to prepare the products ourselves.

A British firm, which had built huge mills in Scandinavia for the preparation of the essential raw material, disposed of its financial interests to a foreign concern. The bargain was settled for a round £7,000,000—$35,000,000! Surely this transaction suffices to demonstrate that there is big money to be made preparing paper pulp, as the raw material is called, for British paper mills. The fact that in pre-war days we imported a round 2,000,000 tons of pulp and paper during the course of the year serves to convey some idea of the magnitude of the industry, and the extent to which this country became dependent upon foreign sources of supply.

One hundred years ago, or even less, the British paper-making industry was a staple. The paper was British made from British materials. In the light of this knowledge one may well ask why, and how, we allowed this profitable trade to slip through our fingers? The cause was not far to seek. Our old pugnacious friend the wasp was primarily responsible for the passing of this British industry. He, from his paper-making prowess in the fabrication of his wonderful nest, set certain imaginative men thinking hard. If this humble insect could contrive such a remarkably tough and stout paper for home-building purposes from wood surely it was not beyond the wit of men, with the bewildering array of mechanical and chemical handmaids at his elbow, to do likewise!

Accordingly the observant, fertile, and patient minds went to work. Within a short time they not only succeeded in imitating the wasp, but evolved such a simple process in the doing of it as to make an irresistible appeal to commerce. Incidentally while this one line of investigation, the purely mechanical, was being pursued other equally brilliant minds were perfecting a second means of achieving a similar end by mechanical-chemical agency. In this manner commerce became equipped with two efficient means for the reduction of trees into paper, and at such a low figure as to render the conventional competitive methods impossible, at least for the cheapest grades of paper, such as are employed for our newspapers, popular periodicals, and low-priced books.

To reap the rich rewards which invention dangled before commerce only two fundamental requirements had to be fulfilled. The one was ample cheap power in close proximity to virtually inexhaustible supplies of the essential material, namely soft woods, which constituted the second factor. Scandinavia held unrivalled attractions in this respect. Accordingly the princes of the paper-making industry trekked to Norway and Sweden, to convenient points amid the endless reaches of forest, and there planted huge mills beside waterfalls and swiftly running rivers, which were harnessed to provide the cheap power which hydro-electric energy offered. The outlook was additionally alluring from the circumstance that these mills, metaphorically speaking, could be established within the proverbial stone's throw of the biggest and most promising markets of the world.

So Scandinavia succeeded in building up a rich monopoly which experienced continuous prosperity until a few years ago. Then similar activity became manifest in certain corners of Farther Britain, notably in Newfoundland, Eastern Canada, and British Columbia, where, owing to the prevailing climatic conditions favouring huge reserves of suitable forests, ribbed with abundant water power, a bold bid was made, not only for the European but the American markets as well. For the first time in its history the Scandinavian interests were brought full tilt against powerful competition.

With the advent of the halfpenny newspaper, the popular periodical, and the cheap edition of a favourite author, all of which depend upon mammoth circulations for their financial successes, the wood-pulp industry received a

tremendous boom. In 1913 British imports from Scandinavia aggregated 756,252 tons valued at £3,533,509—$17,667,545. Germany, attracted by the glamour of the commercial possibilities held out in this direction, essayed to participate in the boom, her exports of pulp to these islands during the above-mentioned year reaching 40,972 tons worth £330,456—$1,697,280. In comparison with the figure for Scandinavia the Teuton contribution may appear small, but it must not be forgotten that this represented a 50 per cent. increase in Germany's favour within two years. During the year in question Canada and Newfoundland also swelled the home market, the aggregate of pulp and paper accepted from their mills by Britain being 119,742 tons valued at £279,374—$1,396,870.

Then came the war, and this upset the upward tendency of the foreign manufacturers to an alarming degree, as well as causing distinct stringency among ourselves. Germany was knocked out of the market in one blow, while the demand for shipping likewise extinguished the Canadian contributions. Then came the appointment of a Controller to adjust the Scandinavian situation, and official action in regard to restrictions, which were admittedly severe, threw the Scandinavian industry all sixes and sevens. Some idea of the degree to which the imports of paper and pulp from Scandinavia were hit may be gathered from the figures for 1918—390,000 tons as compared with the pre-war supply of 2,000,000 tons, representing a fall of 82 per cent.

The situation at home assumed an ominous aspect. Cutting off imports reduced supplies to a figure hopelessly below demand. The issue was further aggravated from the circumstance that the domestic industry had not been advanced to the position where it could take up the producing reins to make up the deficiency. The output from British mills during 1918 only approximately equalled the importation for the year, and was less than double the figure at which it stood five years before, which was about 200,000 tons.

In these circumstances the Controller was called upon to make a round 700,000 tons of paper go as far as had 2,000,000 in pre-war days. As a matter of fact the last-named figure was short of the mark, for the simple reason that sources of consumption, and heavy ones at that, which had been non-existent five years previously had sprung

up and were in the full blaze of activity. I refer to the various Government departments created as a direct result of the war.

Where does all the paper go? To the lay mind this question appears impossible of a comprehensive answer. He concedes that the publishing and commercial worlds, from the magnitude of their operations, must absorb colossal quantities, but this reflection does not bring complete comfort. During the war period it was not so difficult to reduce the apparent enigma to simple explanation. The Stationery Office devoured paper to the extent of 57,000 tons a year. The Ministry of Munitions absorbed 1,000 tons a week in the actual manufacture of missiles, one use being the substitution of aluminium by paper for filling the tips of bullets, while fuse cylinders were also contrived from paper instead of from tin. The Ministry of Food called for 400 to 500 tons of paper to provide the cards for sugar, meat and butter rations, while the issuance of the subsequent ration books ran away with another 750 tons. The War Office was probably the heaviest consumer, from the simple fact that all jams and preserves issued to the army, and packed in one-pound consignments, were served in paper cartons instead of tins. Seeing that the quantities of jams issued in this manner ran into millions, the consumption of paper for the containers was stupendous. Such zealous and ingenious recourse to paper instead of metals for such purposes was readily explicable. For instance, at the time, tin was costing about £320—$1,600—per ton as compared with brown paper at £35—$175—and cardboard at £50—$250—per ton respectively. It was to the advantage of the nation to abandon costly metals whenever and wherever a paper substitute was equally serviceable.

To counteract the shortage in supplies from abroad every effort was made to extend and to develop the domestic manufacturing facilities. This was not such a simple task as it appeared, inasmuch as we are sadly lacking in the reserves of the necessary material. We possess no soft-wood forests waiting to be turned into paper. In these circumstance the alternative was to embark upon a voyage of discovery and experiment in the hope that an efficient inexpensive range of substitutes might be unearthed to take the place of the imported wood-pulp, either

exclusively, which was scarcely to be expected, or to a very pronounced degree.

Official intervention brought home to us one very heavy wastage. This was in regard to the pulp which we imported. Two different kinds of pulp are produced abroad: The one, produced after the manner practised by our friend the wasp, but by mechanical agency, is known as mechanical pulp; the other, contrived by the aid of chemicals, is commercially known as chemical or sulphite pulp. In so far as the first named was concerned official investigation revealed that the Scandinavian mills were accustomed to send the article in a wet form. Now, seeing that wet pulp comprises 50 per cent. of moisture, it will be seen that the vessels bearing this commodity—and tonnage was severely limited—were really working only to one-half of their actual carrying capacity. With every ton of pulp the ships were compelled to carry one ton of water, and to ship water to Britain is comparable with sending snow to Greenland.

The Scandinavian mills were more than willing to ship wet pulp by the thousands of tons, and the British paper-makers were every whit as ready to receive it. To obtain the raw material in this form facilitated, expedited and cheapened the actual paper-making process. It was another instance of British readiness to sacrifice every other interest upon the altars of cheapness and minimum of effort. The Controller, naturally, demurred against paying freight for the carriage of water which is only too abundant in these islands, and forthwith demanded that the pulp should be sent over in the dry form. In this manner he achieved a laudable object: he doubled the quantity of pulp supplied to Britain without calling upon a further ton of shipping for the purpose.

The pulp-makers of Scandinavia, and the paper-makers of Britain, objected to this rational action. Strong protests were levelled against the new order. The affected interests went to great length to explain that the wet pulp was essential, and advanced their reasons—technical, financial and otherwise, but they failed to upset the decision which had been made. The Controller was not seeking the unattainable, because a certain proportion of dry mechanical pulp has always been shipped to this country. It was merely another instance of affected interests desiring to achieve their re-

spective purposes along the lines of least resistance. In no circumstances, normal or war, can the conveyance of water with raw material to these islands be justifiable.

The reason why the pulp-maker was so anxious to ship his pulp wet was because under such conditions he could market it at a lower figure and dispatch it with greater facility. The paper-maker championed the wet form for the reason that it was more convenient to him; he was able to turn it straightaway into his machines. But when imported dry the pulp must be subjected to certain preliminary treatment which involves time, trouble, and a certain expense. Consequently, out of 100 tons of mechanical pulp normally shipped to Britain, only one ton was in the dry form; the other 99 tons were in the more handy wet form. Certainly there are accepted technical objections to dry pulp. It is brittle and apt to chip. But wet or dry it cannot be used exclusively and solely in the preparation of even the lowest grades of newspaper. A certain proportion of the chemical pulp must be added to impart the requisite degree of firmness and stoutness to the fabric.

A little investigation reveals why the Scandinavian pulp-makers were firmly set upon shipping the pulp wet. In pre-war days the British paper-maker paid from £2 5s. to £2 10s.—$11.25 to $12.50—a ton for the moist pulp delivered at a British port. Freight was a mere bagatelle, averaging about 5s.—$1.25—per ton. To convert the wet into dry pulp prior to shipment the Swedish pulp-makers must use coal. This, thanks to hydro-electric energy, is not required in the fabrication of the actual pulp. But Sweden is deficient in coal resources and compliance with the British official request involved the importation of British coal. Inasmuch as it takes from 1,120 to 1,680 lb. of coal to dry one ton of pulp it will be seen that the Swedish manufacturers were faced with a fuel bill which was likely to run into big figures. Under war conditions British coal was expensive, while quality was subject to wide variation. At that time the coal commanded from £8 to £10—$40 to $50—per ton in Sweden. Consequently, to his disgust, the pulp-maker was confronted with the necessity to incur an extra manufacturing charge ranging from £4 to £8—$20 to $40—per ton of pulp produced.

It is to be feared that the Swedish manufacturers, while

anxious to sell as much as possible to, were very reluctant to buy, from these islands. They denounced the British official decree in no unmeasured terms, and sought by every means in their power to secure its withdrawal. But for once British authority was not solicitous of the interests of the foreigner. Recognizing the futility of protest the Scandinavian makers set to work to comply with our demands, and so shipped the pulp in the dry form. We received the benefits accruing from this line of action because we received twice as much pulp as formerly for the same amount of tonnage. True, it cost us more, the price running up to £32—$160—per ton, but it is to be feared that the foreign manufacturers took full advantage of the peculiar situation which prevailed in accordance with that inexorable law of supply and demand, although they maintained that their manufacturing charges were heavily inflated, not only from the purchase of the necessary coal, but from the higher wages which labour demanded. But even at the above figure we derived distinct advantage. Seeing that one ton of dry represented the equivalent to two tons of wet pulp we were really paying at the rate of only £16—$80—per ton, less the sum which had to be deducted from the sale of our coal. Restriction of freight had a good deal to do with the enhanced prices. Only 250,000 tons of shipping a year were allocated to this traffic, and what cost 5s.—$1.25—a ton to ship in 1913 cost £13—$65 per ton in 1918. British ships participating in this trade were thus able to get back something of the heavy prices we paid to the foreigner for an indispensable commodity. But even £32—$160—per ton for dry mechanical pulp contrasted favourably with the chemical pulp, also shipped dry. This, which before the war cost £7 10s.—$37.50—per ton shot up to £47—$235—a ton at one period, and recorded £35—$175—per ton during 1918, while paper, even of the lowest grade, which commanded £10—$50—a ton in 1913, realized £45—$225—per ton in 1918.

Contemporaneously with the adjustment of the various questions pertaining to the Scandinavian pulp and paper, the authorities set to work to develop the domestic raw material industry. Obviously the most promising founts were rags and waste-paper. It was computed that, if these available sources were fully exploited, it would be possible

to secure some 300,000 tons of suitable material during the year.

However, it was seen that the first step would be to instil into the minds of the community the necessity to observe rigid economy in the use of paper. Rationing brought home the fact that a paper shortage existed, and, of itself, led users to be more sparing in their uses of this article, in precisely the same way as similar measures effected comparative results in connection with foodstuffs and other commodities. But in so far as paper is concerned it is difficult to preach the gospel of economy; it has been ridiculously cheap and abundant for far too long. Nevertheless much was accomplished, but whether the lessons thus imparted have been taken sufficiently to heart as to become ingrained is problematical. Reversion to former conditions will probably promote a state of affairs as bad as, if not worse than, before.

The wasteful consumption of paper was by no means confined to any particular class of the community. Industry was every whit as improvident. For instance, the soap-making trade naturally absorbs immense quantities of the article, but the manufacturers were shown how, by practising simple saving methods, they might do with 10,000 tons less per year, which, at the prices then prevailing, represented a round £350,000—$1,750,000—per annum. To one firm alone the suggestion represented a possible economy of £75,000—$375,000—a year. What is possible of attainment in the soap-making industry is equally feasible in other trades, especially those identified with provisions. If such broad economies be carried out they could scarcely fail to exercise, under competitive trading conditions, an appreciable influence upon the price of the products concerned. Consequently, paper, as already indicated, has a more or less direct bearing upon the cost of living.

The wastage of paper throughout the country is appalling. Upon the completion of its designed function the material is either burned, consigned to dust-bin, or allowed to pursue an aimless journey at the mercy of the wind through our highways and byways. People of a thrifty turn of mind undoubtedly save their waste, disposing of it at intervals to itinerant collectors, who acquire the litter of the house in exchange for something more or less attractive, if not useful, in kind.

Previous to the war very little of this waste found its way back to the domestic paper mills to be re-made. The percentage of waste blended with new pulp was very low, certainly not more than 2 per cent. Even this was almost entirely restricted to what is known as "broke," that is the trimmings from the reels when repairing breakages in the continuous lengths running through the printing or paper-making machines.

Strange to relate, nearly the whole of the waste-paper recovered from the household, office and factory was exported, principally to the United States of America, until an American firm, discovering Britain to be a waste-paper mine, established itself in our midst to salvage an appreciable quantity of what we regarded as a nuisance. This refuse was utilized as raw material for the manufacture of paper-boards, the American analogue to our familiar strawboard, to form book covers, stout packing, and to meet other conditions where adequate protection to contents is demanded. This became a prosperous undertaking and afforded merely another instance of how the stranger within our gates has been able to reap material profit at our expense and through our folly.

Although this firm absorbed an enormous quantity of our waste-paper it could not cope with the avalanche of this refuse. Many additional thousands of tons were shipped annually to the New World to be worked up. It seems remarkable that the Americans should have found it profitable to collect our residue, to freight it across 3,000 miles of ocean, and to fabricate therefrom their particular range of goods, instead of turning the material available on their own side to such account. But the venture proved decidedly profitable as the results testified. Indeed, it was the enterprise of this pushing firm which first brought home to us the wealth capable of being derived from the commercial exploitation of waste-paper, and which led us to introduce a collecting system upon an organized basis.

When the authorities grasped the significance of the waste-paper issue they promptly took steps to retain the whole of the residue in these islands. Export was prohibited; it could only be returned to British mills. A country-wide appeal was made urging every trader and every private citizen to conserve his waste-paper, whether it were used

envelopes, newspapers, postcards or fragments of brown paper. So urgent became the demand for this raw material that housewives were requested to ransack their cupboards and lumber-rooms for odds and ends of every description in the paper line—old novels, abandoned magazines and what not; business houses, workshops, and factories were invited to indulge in spring-cleanings to turn out musty files of old letters, receipts, memoranda, obsolete account books and other accumulations; paper hangings stripped from walls in course of redecoration, instead of being burned, were sedulously bagged; even hoardings were divested of their hard thick hides of superimposed posters to provide food for the paper mills. Municipal authorities were urged to participate in the round-up, since it was recognized that imposing quantities of paper evaded all other methods of recovery from inadvertent committal to the dust-bin. In another chapter I have indicated what was done in this direction.

The authorities stimulated the great national paper-chase by every possible artifice. Waste-paper organizers, to the number of thirty-five, were appointed to various parts of the country to foster and to supervise the collection of this refuse. Licences were granted to approved merchants authorizing them to deal in the article. Prices were fixed and graduated according to the quality of the waste, and upon a liberal basis to encourage one and all to conserve and to hand over their accumulations of what they considered to be sheer rubbish. In this way waste-paper was poured back into the British mills for remanufacture in a steady stream of 4,300 tons a week. For a time the volume was maintained, but then it gradually and persistently declined because as the founts became exhausted the quantity of paper put back into circulation suffered a steady decrease.

Despite the elaborate precautions observed, and the salvage organizations instituted, a vast quantity of the refuse escaped recovery. Paper is something like the elusive pin: where it goes no one appears to know. During the period when salvage was being pressed home with all vigour the British mills were turning out about 700,000 tons of paper a year. Of this aggregate approximately one-fifth —150,000 tons—went to the army in the field in France

in some form or other. A further 150,000 tons could not be expected to be recovered as waste, being either retained or submitted to certain necessary applications such as filing, the lighting of fires, and so on. This left a balance of 400,000 tons which went into circulation, but of which only 200,000 tons were retrieved to be sent back to the mills to be repulped. What became of the outstanding 200,000 tons it was impossible to say: it simply disappeared. Probably much suffered destruction through ignorance, while no doubt much was lost through being soiled to such a degree as to be beyond redemption. But the fact remained that of the 700,000 tons produced at least 50 per cent., or 350,000 tons—including the 150,000 tons sent to France—were completely lost, whereas by the exercise of a little forethought, care and trouble the greater part thereof might have been retrieved. Through negligence or ignorance the nation was losing a round £3,350,000—$16,750,000—a year, because the paper was worth at least one penny—2 cents—a pound in the waste form.

From the magnitude of the absolute losses it is obvious that we could never have sustained ourselves for long upon the forthcoming supplies of waste-paper and the diminished foreign imports of pulp to serve as raw materials. Accordingly search was made for other potential raw materials of domestic origin, the governing principle of this mission being to place the country in such a position as to be quite independent of the foreigner in all matters pertaining to paper, not only during the war period, but after the cessation of hostilities.

Paper, in one respect, is a curious manufactured product. It can be made from almost any fibrous material with the exception of wool. The knowledge of this fact prompted members of the general public to advance the claims of divers and wondrous substances. As may be readily imagined, the majority of these suggestions erred somewhat upon the side of the fantastic and chimerical. The mere fact that paper *can* be made from almost anything does not necessarily imply that it is commercially practicable to exploit even the most obvious raw materials indiscriminately. There is a wide and deep gulf between the laboratory, the cradle of experiment, and the factory, the home of application. In the first-named the factor of cost of production does not count; in the last-named it constitutes the crux of the

issue. Consequently the majority of the recommendations submitted by the uninitiated suffered from the disability of being perfectly feasible but hopelessly impracticable. Submission of a suggestion to the cold, unrelenting, unsympathetic manufacturing analysis and subsequent translation into pounds, shillings, and pence offered the incontestable reply to the inevitable question "Will it pay?"

One article of domestic origin, the spartina, or common couch grass, which thrives in abundance upon many stretches of our coastline, notably Hampshire, was responsible for an avalanche of letters containing inquiries as to why this material was not being turned to account. Apparently every individual who had visited the neighbourhood of the Solent, and had observed the density of this growth, assailed the authorities for their lethargy. Esparto grass was imported from Spain to make paper, and yet here we were ignoring a readily obtainable indigenous grass similar in every respect!

But the claims of spartina had been promptly investigated—to be found wanting. In the first place, when a new material appears to be promising the question as to whether sufficiently imposing supplies could be forthcoming must be considered carefully. The paper-making machines are insatiable and avaricious, devouring raw material not by the ton but by the thousands of tons. This in turn gives rise to the question as to the cost of securing the necessarily heavy supplies. One enthusiast, who had advanced the claims of the couch grass, was interrogated upon the subject because he had evolved a means of gathering the spartina. When he was asked the cost of his process he blandly replied that he could do it for £15—$75—per ton. He received a shock when he was told that there was another material, forthcoming in far greater quantities, and far more suitable for the purpose, which could be obtained and delivered to the mill for £4 10s.—$22.50—a ton! I may remark that spartina grass is being used for paper-making where the conditions favour its cheap collection and transport. Speaking generally, however, with prices at an artificial level, any material costing more than £5—$25—per ton delivered at the mill—this figure is inclusive of collecting, transport, and other charges—stands little chance of favourable con-

sideration. Under normal trading conditions the prospect will be even less attractive.

The acquisition of the raw material represents merely the preliminary phase of the whole issue. To reduce it to pulp involves the consumption of coal—cheap water-power is rare in these islands—and so the probable fuel bill requires to be sounded. How many tons of coal will be required to produce a ton of pulp? It is a simple question and one which prompts another, closely allied thereto, namely, "How many tons of such-and-such material will be required to furnish a ton of paper?"

This is the rock upon which many buoyant expectations have been completely wrecked. Still confining ourselves to the couch grass, and considering the second factor first, we find that it has rather a low yield efficiency, this being in the neighbourhood of 27 per cent. In other words, it will require nearly four tons of crude grass to produce one ton of paper. When ranged beside esparto grass, with which it seems to have much in common, and which therefore is a convenient comparative unit, the outlook for the couch grass is completely shattered, because the efficiency yield of esparto is high, 43·5 per cent. Only a little more than two tons of grass are necessary to produce one ton of paper.

But the fuel factor is far more destructive to the claims of the waste grass growing upon the seashore. To make one ton of paper from esparto grass, under the most favourable conditions, requires 3 tons of coal. In actual practice it ranges from 3·5 to 4 tons. But with spartina grass the coal consumption is forced up to 5, and even to 7, tons under the unfavourable conditions prevailing in many paper-mills. Accordingly, it will be seen that couch grass cannot be construed into an attractive raw material for paper. I may say there are other objections to its use, but the foregoing are sufficient to bring about its rejection in this phase of utility.

Even if we take those materials which are accepted as being the most favourable to the manufacture of paper we gain enlightenment. One ton of waste-paper will not yield one ton of new paper as might be imagined. The loss in re-manufacture is about 25 per cent., so that from the 58,000 tons which enter into the made waste of the country we could produce about 44,000 tons of new paper. Cotton

rags have a high yield efficiency, being in the neighbourhood of 85 per cent. and upon this basis we might safely expect a yield of some 16,000 tons of paper from the 19,000 tons of rags committed to the dust-bins of the country.

It may be mentioned that in the search for indigenous materials whence paper might be manufactured, the whole gamut of obvious domestic contributions to the issue have been examined, including such substances as sawdust, wood-shavings, wood-slats, grasses of which there are over 100 varieties, mimosa bark, peat, straw, flax-wastes, flax-shoves, and dried potato vine. Of this wide selection only four materials hold out any promise of extending commercial possibilities. These include sawdust, wood-shavings, wood-slats and straw, with potato haulm serving as an excellent material for the fabrication of a coarse, strong, brown packing paper. Of course, it must be explained that these materials are in addition to those generally utilized in the industry, such as rags, sacking, bagging and reeds, to mention only a few substances.

The definite end sought in the first instance was not so much the discovery of suitable substances to supersede entirely the imported mechanical and chemical pulps, as the presentation of materials which might be considered effectively as useful for dilution purposes. By this is meant the production of a pulp, made perhaps from some familiar product, which, when added to a certain proportion of the conventional pulp, would yield a paper comparable with that derived from the last-named exclusively. Any success recorded in connection with a diluent offers the means to enable a specific quantity of the imported raw material to be induced to go farther than would be the case otherwise, this tendency becoming accentuated as dilution is increased.

It was essentially in this light that the feasibility of pressing sawdust, wood-slats, and other wood and vegetable refuse was considered. Of course, behind all these developments, experiments, and researches, there has been the lingering hope that ways and means might ultimately be found of enabling us to dispense with outside sources of supply in their entirety. This hope still prevails, and, if properly fostered, may lead to realization. But to consummate such an end it is essential to employ materials capable of yielding a pulp as closely resembling the article derived

from the tree as possible. Patient investigation proved that sawdust offered the most attractive possibilities in this connection.

While doubt has been expressed concerning the adaptability of sawdust to this duty there are the experiences of Canada and the United States to guide us. Indeed, we need not go out of these islands to obtain confirmatory evidence of its applicability to paper-making. Britain pioneered the utilization of sawdust for the manufacture of paper, and, by a strange coincidence, it was the Napoleonic wars which compelled us to resort to such a manifestation of enterprise. With the exit of Napoleon from the world's political stage the necessity to exploit sawdust in this connection disappeared, and so the process fell into disuse, to lie dormant for a round one hundred years. Consequently the use of sawdust really represents but a revival of an old practice.

But, so far as these islands are concerned, and under normal conditions, sawdust can scarcely be regarded as a paper-making material. The quantity available from our sawmills is too meagre to enable the idea to be practised extensively. There is just one chance of placing the development upon a firm footing. We are big consumers of timber, but the greater part of our requirements in this field are satisfied by importing supplies in a manufactured condition. Attempts are being made to restore the British wood-working industry by importing lumber in the slabbed condition, that is square trimmed logs either in the form of huge rafts or demountable ships. Should this development mature then our sawmills will become clogged with huge accumulations of wood-waste in the form of the sawdust, the exploitation of which will be keenly appreciated.

During the war, however, the necessity to exploit the forests of Britain to contribute to the requirements of the army and mines in regard to wood has resulted in the piling-up of huge heaps of sawdust. It was discovered that in Scotland alone this residue was accumulating at the rate of 60,000 tons a year, through the activity of the Canadian lumberjacks. Conservative estimates place the annual sawdust yield throughout the British Isles at 150,000 tons. Of this gigantic contribution only from 5 to 10 per cent. is drawn from hard woods. The balance, 90 to 95 per cent.,

is derived from the soft woods and so furnishes a huge reservoir of potential raw material for paper-making.

Coincident with the accumulation of sawdust are the fabrication of huge piles of wood-slats—the trimmings from the logs. These also represent sheer refuse, the only possible disposal being in the form of fire or kindling wood. At one lumber-camp in Scotland there was found a pile, a sprawling, ragged and jagged stack, house-high, covering 20 acres, and containing, at a modest estimate, from 300 to 500 tons of wood-waste. It was ideal for paper-making as investigations proved, but was then merely being allowed to rot.

The process of preparing sawdust for the paper-maker is very simple and inexpensive. It may be described as an application of the system for producing mechanical pulp, because, in the main, the resultant product is very similar to the latter in its essential characteristics. The waste, being the product of the buzz-saw, is coarse in texture. It is first passed over a riddle of wide mesh, which, while allowing the dust proper to fall through readily, collects the pieces of bark, chips, and other fragments of wood which may have become associated with the dust. This residue is thrown to one side for conversion by a different method. The sifted sawdust is dumped into a hopper to fall by gravity in a steady stream into the mill, which is somewhat reminiscent of the familiar mortar-mill, below. As it enters the latter it is caught up by the revolving grindstone and crushed against the stationary stone, the result being that it is disintegrated and pulverized. By virtue of the centrifugal action set up the dust, as it is whirled round, naturally works from the centre to the periphery of the wheels, the coarser particles or tailings being flung out, while the finely-divided dust, produced by the grinding action, falls into a separate receptacle.

The tailings are recovered to be re-passed through the mill, and, in time, for the most part are also ground to the desired degree of fineness. A certain proportion of residue defies reduction in this manner, but it is not discarded. It is retrieved to be used in the manufacture of coarse brown paper. Two methods of grinding, even in the vertical mill, are practised. The one known as the wet process involves the addition of water to the dust, which thus becomes hydrated, the resultant saw-pulp, as it is called, being somewhat

similar to the familiar wet mechanical pulp. The alternative process is described as dry grinding, the sap in the wood constituting the only moist agent.

It may be mentioned that, in the very earliest attempts to emulate the wasps' paper-making process, the experimenter ground the wood to dust by applying the log to the face of a grindstone which was revolving, water being the lubricant, the practice recalling the grinding of tools. The particles of wood fell, with the water, into the trough beneath. The surplus water was drawn off, leaving a mashy residue or pulp—hence the name.

In grinding the sawdust the coarse material is reduced to a fine powdery substance, soft and silky in texture when dry, but which retains the essential fibrous characteristic, though naturally the length of the individual fibre is extremely minute. But pulp so produced possesses one advantage for the paper-maker—it demands no preliminary boiling. It can be discharged direct into the beater, as the machine which prepares the raw material for the paper-making machine is called, with the waste-paper, sulphite or mechanical pulp, or a mixture of both, it only being necessary for the agitation of the contents of the beater to be conducted thoroughly to bring about the perfect blending of the ingredients.

I have emphasized the circumstance that this saw-pulp may only be considered as a diluent. This may be varied from 10 to 35 per cent. according to the quality of the paper desired. The issue of the *Times*, dated June 15, 1918, was printed on paper containing 20 per cent. of this saw-pulp, but I have seen other newspapers the paper for which was prepared from pulp diluted to the extent of 35 per cent. with the saw-pulp. With the accumulation of experience in the working up of this material marked improvements are to be recorded in regard to quality of the resultant paper which has enabled dilution to be carried to an enhanced degree without imperilling the factor of strength which the finished product must possess to enable it to be passed through the newspaper printing machine at a speed of 500 feet per minute without breaking. Under modern conditions it is difficult to determine whether or not saw-pulp has been introduced into the composition of the paper, which testifies conclusively to the perfection of production.

This economic utilization of one waste from the sawmill is of decisive financial significance. Cost of production is extremely low, because the power for driving the grinding mill may be obtained by firing the steam boilers either with sawdust itself, the consumption thereof being small, or with the refuse resulting from the preliminary sifting of the dust. Indeed, the process holds out such alluring possibilities that there is no reason why every sawmill should not include a grinding mill to treat the residue on the spot, shipping the saw-pulp direct to the mill, thus turning what is now an unmitigated nuisance and a source of danger into a distinct commercial asset. It is estimated that a grinding mill requiring 25 h.p. for its operation could turn out 1⅛ tons of saw-pulp in the course of the ordinary 8 hours' working day or 7 tons a week. The cost of such a plant would be about £400—$2,000—and the price obtainable for the product should be sufficient to render the conversion of the waste to this useful purpose attractive after paying all outgoings. At the time the practice was brought into operation the cost of reducing the sawdust to saw-pulp of the desired character was from £5 to £6—$25 to $30—per ton. It is estimated that the saw-pulp maker would be equitably rewarded with £8—$40—per ton for the finished material ready for transport to the mill. On this basis a grinding mill, working to full capacity through the 44 hours' working week, should be able to show a gross profit of £21—$105—which should leave an adequate margin of net profit to encourage such exploitation of the waste. The expansion of this young industry, however, depends entirely upon the conditions which will obtain upon the restoration of normal trading. It is a moot point whether the Scandinavian pulp-makers will ever be able to revert to pre-war quotations for their product, owing to the increasing costs of production, and this fact should render the outlook distinctly promising for the home producers, more especially if the sawmill trade be destined to undergo a decided revival. Every ton of saw-pulp produced from the waste will prove beneficial to the nation, for the simple reason that it will enable us to reduce our purchases from foreign sources of pulp by a corresponding amount.

While saw-pulp can only be regarded as a contribution to the paper-making problem, there happens to be another

waste product suitable for this purpose, one which is available in much larger quantities, and the supply of which would seem to be increasing rather then decreasing. I refer to straw. Hitherto we have sadly neglected the many possibilities offered in this connection, having preferred to turn our by-product of the grain fields to other applications and to import vast quantities of strawboard for the manufacture of boxes, containers, and what not. Other countries have been more industrious and enterprising than we, but what they have achieved is equally feasible in these islands. To bring home the magnitude of this industry it is only necessary to relate that our annual pre-war imports of strawboard from Holland reached 250,000 tons.

There is no reason why such a lamentable state of affairs should continue. Straw is not only useful for the production of strawboard, but it constitutes an excellent material for the manufacture of paper. Its yield efficiency, while lower than that of esparto grass, being only 33·3 per cent., is sufficiently high to render its exploitation in this direction highly promising, especially as the material can be obtained in huge quantities.

At the present moment our supplies of straw for civilian needs may rule low and prices may be high. But this is due to the heavy military demands. Once the latter retire from the market and leave the article to take care of itself, a marked drop in price may be confidently anticipated, particularly if our new agricultural policy be maintained. So long as it pays the farmer to grow corn he will continue to do so, and the more acres he brings under this indispensable commodity the greater will be the quantity of the by-product thrown upon the market. It is anticipated that, when things settle down, from 2,000,000 to 3,000,000 tons of straw in excess of civilian needs will be available, and the only possible outlet then for this waste from our grain-fields will be the paper-mill. The utilization of the straw in this direction will be influenced by charges for fuel and labour, while, of course, the price of the imported pulp will affect any decision which may be contemplated in regard to the exploitation of our home resources. But assuming that the Scandinavian pulp will be dearer as a result of enhanced production charges, and assuming that dumping tactics just to hold the market will be frustrated, it is quite possible

that we shall find it cheaper to depend upon our own exertions with domestic materials. If the quantity of straw which I have mentioned should become available and be absorbed for this purpose, it will be adequate to furnish from 670,000 to 1,000,000 tons of paper.

The straw, borne directly from the land, is relatively cheap. The cost, delivered to the mill, even during the war was only about £4 10s.—$22.50—per ton. This figure is likely to fall. It produces an excellent paper, but it is essential that it should be chopped very finely preparatory to treatment, after which it is boiled with chemicals and finally bleached. The yield efficiency being 33·3 per cent. it follows that three tons of straw are required to produce one ton of paper.

But the straw is not only required for the production of paper; it is equally necessary for the manufacture of strawboard. Under war conditions an appreciable quantity of the reclaimed paper was being repulped to furnish card-board and paper-board for packing purposes to make good the shortage prevailing in regard to the Dutch product. But the waste-paper is more useful for paper-making. Accordingly it is being switched over to this duty. It was merely utilized otherwise during the war because it was so urgently required, the national consumption running into approximately 100,000 tons annually. Efforts are being made to establish the strawboard industry in these islands. The Dutch method has been adopted, and there are hopes that the output will be speedily raised to 50,000 tons a year. While this falls far short of the actual imports it represents a bold commencement to emancipate us from the necessity to pay tribute to the foreigner to the extent of nearly £1,000,000—$5,000,000—per year for an article which we might just as well produce at home.

Why do we not undertake the manufacture of wood-pulp in this country? This is an obvious question. But so far as these islands are concerned the absence of supplies of raw material in the form of forests has been responsible for the British abandonment of this range of activity. Anterior to the outbreak of war there were three mills in this country possessing integral facilities for pulping wood by the sulphite process, but it was unremunerative owing to the insufficient supplies of suitable indigenous timber. Two mills permitted

their sulphite plant to fall into disuse and in course of time dismantled them. The third mill maintained operations, though under difficulties, while its contribution was small in comparison with that of Scandinavia, its capacity being only 6,000 tons a year.

The enormous accumulations of wood-slats arising from the exploitation of our forests to meet military requirements turned native thought towards the resuscitation of the chemical system of pulping. A scheme was promulgated for the erection of a plant in Scotland to work upon the *sulphate* process, the proposed site for the plant happening to be in close proximity to one of the largest ephemeral logging camps. By the sulphate system the wood is reduced to a pulp by boiling in a solution of caustic soda, and for this reason is often known as soda pulp to distinguish it from the sulphite pulp. It requires three tons of wood chips to yield one ton of pulp, which incidentally I may mention is one of the strongest pulps known to the paper-making craft. At the time the problem was discussed this pulp commanded £40—$200—a ton, and so manufacture was considered to offer an alluring prospect for British enterprise. The only defect in this pulp is that it is difficult to bleach, and therefore can be used only sparingly in the production of white paper. It is used principally in the manufacture of strong brown papers, such as "thin kraft," the brown paper used for fruit and other bags, or for packing-paper where colour is of minor importance.

Henceforth "kraft" will be in heavy demand for quite a new range of activity. This is the production of paper textiles in which British inventiveness has far out-distanced the German achievements in this field. At the moment the British company specializing in these textiles is being called upon to pay £40—$200—per ton for its raw material drawn from Scandinavia, so that any fall in price which was anticipated as a result of the cessation of hostilities, which would be likely to undercut British production, has failed to materialize so far. It may also be mentioned that British enterprise is quite ready to bring over illimitable quantities of soft woods from the forests of Eastern Canada in the log condition, and at a rate which is far cheaper than that which has hitherto prevailed. This is due to a complete revolution which has been wrought in the water movement

of lumber, and it will not only enable the requisite material to be acquired at a figure severely competitive, but allow much of the waste lumber in Canada, at present being ignored, to be submitted to commercial service.

But the exploitation of the foregoing materials by no means exhausts our possibilities in this field. There are other substances, of a refuse character, possessing undoubted virtues for paper-making. Among these may be mentioned potato haulm. There is every indication that our output of the potato will record a decided increase owing to the development of industrial science in other fields. Consequently it is only logical to expect increased accumulations of the bine. At the present moment the vegetation in question is regarded more or less as useless. It should be turned back into the ground to assist in feeding the soil, but many farmers are disinclined to follow such a practice for the reason that the bine is apt to foul the plough, and thus delay the ground-breaking task. Its fertilizer content, or rather the phosphoric acid and potash constituents, are generally reclaimed by burning the bine and turning in the ash, but this process is to be deprecated inasmuch as the whole of the valuable nitrogen content is lost.

The haulm, owing to the nature of its fibres, is held to be an excellent material for the production of brown paper where strength is the essential requirement. So a British inventor devised what may be described as a kind of decorticating machine to rend the tough fibre to pieces upon the spot. The machine is simple, free from liability to easy derangement, and ingenious. It is suggested that it should be acquired by the farmer to permit the treatment of this waste as recovered during the lifting season. It is held to make especial appeal to the agriculturist possessing a motor-tractor, the requisite energy being drawn therefrom through belt and pulley. It is estimated that the manufacture of the machine, upon a sufficiently large scale, will enable it to be sold at about £100—$500. The shredded stalk or fibre should be able to command from £4 10s. to £5 10s. —$22.50 to $27.50—per ton at the mill and should appeal to the paper-maker owing to its high yield efficiency, which is in the neighbourhood of 65 per cent. Of course, the suggestion that this waste should be recovered for the production of paper is one that can only be entertained by the

large grower, but it is computed that at least 1,000 machines would be necessary to cope with the country's annual output of this refuse.

Another waste product which has also been subjected to test, and found promising, is the husk from the oat which accrues from milling. The useless offal resulting from grinding this grain is approximately 35 per cent. In its general characteristics the oat-husk closely resembles saw-dust, while its preparation for paper-making entails a broadly identical process—passage through a grinding mill to reduce the residue to the desired consistency. Investigations proved the suitability of this husk-pulp as an ingredient for making certain low-grade papers, such as are used by grocers, and for the very cheapest literature. Paper so made is composed of oat-husks, 35 per cent.; waste-paper, 50 per cent.; imported pulp, 15 per cent. But the most gratifying feature of such paper is that it can be made from domestic raw materials—waste—to the extent of 85 per cent.

It is evident, from what I have related, that the paper situation need never occasion us any undue alarm. We have abundant materials available in the form of waste which we might exploit to our material and financial profit. War, with its concomitant evils, has turned the world upside down. What we could not exploit previously to advantage, owing to severely competitive prices, is now rendered feasible. It only remains for us to submit the results of proved experiments to actual commercial practice.

CHAPTER IX

SUPPLYING INDUSTRIES FROM THE DUST-BIN

DURING the past few years no effort has been spared to improve the health and well-being of the community. Laws innumerable have been passed compelling the mitigation of nuisances and the removal of menaces to hygiene. These efforts are laudable, but, while thay have achieved the desired end, they have been directly responsible for many other shortcomings. The greatest of these is waste, more especially in so far as it affects the household.

Probably no other factor has contributed so materially towards the factor of heavier domestic prodigality than the provision of the portable dust-bin, and the introduction of systematic and regular collection of the flotsam and jetsam contributed thereto. The very convenience which the dust-bin or ash-barrel represents has served to accentuate household extravagance. "Throw it in the dust-bin!" is the popular slogan in domestic circles. Consequently this receptacle has become the harbour for much domestic refuse which, under previous conditions, would never have been so summarily discarded.

This disposition to be wasteful might have been checked, or at least the errors of the domestic circle might have been rectified very considerably, but for one disturbing element. We became such devout worshippers of hygiene as to become insensible to all reasoning. A few years ago the practice was to discharge the contents of the ash-barrel upon open waste land. A small army of workers, even the nomadic element of the community, turned to and raked over the spoil from our homes very diligently. In this way immense quantities of odds and ends in infinite variety which otherwise would have been lost found a market as raw materials for

many industries. Even the ultimate organic residue fulfilled a mission of utility and one in consonance with the laws of Nature, because, in the process of decomposition, the nitrogen and phosphoric acid contents of the dump suffered release to feed the soil to raise sustenance for man and beast.

But ransacking the garbage heap was declared to be a degrading and health-menacing occupation and practice. Indeed, the whole system of household refuse disposal was held up to obloquy. Reform was achieved by the energetic advocacy of another means wherewith to cope with such waste. It received widespread support because it fully coincided with all the requirements of hygiene, while, furthermore, it was simple, expeditious, effective and apparently cheap.

This was destruction by fire along so-called scientific lines. The new idea arrested public fancy mainly for the reason that its champions laid emphasis upon the fact that it presented the possibility of obtaining energy to generate electric light and power and to drive tramways for nothing. Municipalities became affected with the incineration fever. Steam was necessary to drive the electric plant which had been acquired. Why not cut down the coal-bill by making use of the fuel properties possessed by household refuse? The contents of the domestic dust-bin are so varied, ranging from waste-paper, grease-laden bones, fragments of fat, cinders, rags and vegetable odds and ends as to present, in the aggregate, a readily combustible mass possessing distinct calorific value. By utilizing the garbage, which has to be collected, in this manner, the coal-bill might be reduced by so much.

So argued the advocates of the new idea, and their reasonings proved so specious as to gain the day. The prospect of being able to get "Something for nothing" was so alluring as to silence effectively all adverse criticism. Of course, it was futile to gainsay that cremation could be rivalled as a prompt, simple, and completely sanitary means of coping with the refuse which accumulates in every city and big town. Forthwith destruction by fire became the widely-accepted means of getting rid of the unsightly and unsavoury contents of the dust-bin.

Yet the coming of the dust-destructor proved to be a distinctly retrograde step in the science of economics. It

contributed to increased improvidence in the home, because the ash-barrel became the receptacle for a still wider assortment of organic material than ever before, and in greater bulk.

It must be conceded that not all of the garbage which suffered this fate was destroyed to futility. A certain volume of steam was certainly raised wherewith to drive the electric generators, but the amount of energy obtained in this way was out of all proportion to the quantity and value of the material incinerated. In certain cases the destructor was not harnessed to the power station. The ratepayers have not experienced any sensible relief in regard to the fuel bills. Even incineration of household refuse, despite the proportion of its combustible contents, cannot be conducted satisfactorily without the consumption of a certain volume of coal. And the process precipitates a certain quantity of further refuse, in the form of clinker and ash, the economic disposal of which has provoked another and even more perplexing problem.

When necessity, which knows no law, compelled us to economize in every direction, and particularly in connection with food, we found it expedient to turn round to ascertain whether or not we might be able to effect tangible savings to minimize the disconcerting influences of stringency. The domestic dust-bin was the first factor in the domestic circle to undergo sensational overhaul. Material which had hitherto been consigned to this dead end only too freely and perfunctorily, was more closely scrutinized to see if it could not be induced to yield further useful service before suffering complete abandonment by the housewife. Contemporaneously with this manifestation of individual private effort the civic and municipal authorities were compelled to display unwonted activity. The whole problem of refuse disposal had to be viewed from quite a new angle.

Upon investigating the issue of household refuse at close quarters, and under the microscope of concentrated interest, the country's wastage in this direction was found to exceed the wildest speculations of the critics. For the first time illuminating statistics became available. According to the National Salvage Council, the official department created to stimulate the public mind in matters pertaining to this question, the quantity of refuse "made" by householders

throughout the country during the year may be set down at 9,450,000 tons.

At first sight this figure seems so startling as to be received with incredulity, but analysis suffices to demonstrate that it does not err upon the side of exaggeration. Rather is it conservative. It is based upon an allowance of 1,680 lb. a day for each 1,000 members of the total population during 300 days of the year. An allowance of 1·68 lb. per head per day wastage cannot be construed as excessive. How many households of six persons can show a weekly dust-bin collection weighing less than 60 lb. especially when the extremely varied contents of the receptacle are born in mind ?

Now, of what is the heterogeneous collection of the dust-bin composed, and what is the proportion of each to the aggregate ? The following table, based upon the data collected by the official department already mentioned, shows—

Material.	Average Percentage.	Total per Year.	Estimated Value.	
		Tons.	£	$
Fine dust	50·98	4,800,000	240,000	1,200,000
Cinders	39·63	3,700,000	1,850,000	9,250,000
Bricks, pots, shales, etc.	5·35	500,000	25,000	125,000
Tins	0·98	90,000	360,000	1,800,000
Rags	0·40	37,000	555,000	2,775,000
Glass	0·61	50,000	100,000	500,000
Bones	0·05	4,000	—	—
Vegetable matter ..	0·72	68,000	—	—
Scrap iron	0·06	5,000	15,000	75,000
Shells (oyster, etc.) ..	0·08	7,000	—	—
Paper	0·62	58,000	400,000	2,000,000

From these figures it is evident that the dust-bin is a veritable treasure ground. Of course the values are subject to market fluctuations, but it is apparent that a round £3,000,000—$15,000,000—more or less, a year, is being allowed to fly up the chimney to vanish in smoke and gases, and to extend very meagre return for its combustion.

Let us consider the despised homely cinders as an illustration of how we permit wicked waste to reign in the household circle. According to the table they represent approximately

two-fifths of the total contents of the dust-bin, and make up the respectable aggregate of 3,700,000 tons a year for the whole country. As a straight fuel the cinder is but slightly inferior to coal. When washed its calorific value is about 10,000 British Thermal Units. Good steam coal only averages 14,000 British Thermal Units. Accordingly the spurned cinder, from the heat-raising point of view, is worth about five-sevenths of coal drawn fresh from the mines. The householders of Britain have been content to throw away 37,000,000,000 British Thermal Units every year in ignorance. Translated into terms of coal this is equivalent to 2,642,857 tons. In other words we have wasted what is tantamount to two-and-a-half millions of high-grade coal every year, and have spent money on fuel which we might just as well have kept in our pockets or have turned to other beneficial purposes. Obviously, if every house undertook to turn its cinders to full account, the domestic call upon the mines might be materially reduced, while there would be an appreciable contribution to the conservation of our coal resources from such a practice.

Paper is another commodity which, in the past, we have handled along woefully improvident lines, as related in the previous chapter. We have not even taken the trouble to burn it, but have permitted it to drift and flutter hither and thither to find a final repository, grievously soiled and dirty, in the dust-bin. But even when so marred and deteriorated it was worth, during the war period, no less than £7—$35—a ton!

The wastage of rags, both cotton and woollen, has been even more deplorable. In this instance, however, possibly a reasonable excuse for the prompt consignment of such material to the dust-bin and the dust-destructor can be advanced. Popular opinion regards textile odds and ends as an ideal vehicle for the transmission of the germs of disease. Yet such does not justify the indiscriminate committal of material worth £15—$75—per ton to incineration. Infected rags should be burned forthwith in the household fire. But are they? Investigation would probably reveal the disconcerting fact that they are thrown into the dust-bin, as offering the most convenient means of disposal. Even if they should be above suspicion when discarded, the chances are that they become contaminated in the ash-barrel. Consequently

upon recovery such materials should be subjected to preliminary inexpensive sterilization to ensure the public safety.

When the necessity to practise household salvage upon a comprehensive scale became imperative, a few discreet inquiries were made to secure reliable statistics as to what wealth is ignored or thrown away by the community of these islands. The results were somewhat surprising.

In Sheffield, a city of some 500,000 persons, 56,000 jam-jars were recovered in one week through a special collection conducted by school children. They realized 6 shillings —$1.50—a gross, and so brought in £120—$600. In Leicester the practice is, or was, to dispose of certain articles to the local marine store dealers after collection, and to divide the profit arising from the transaction among the employees engaged in the refuse-gathering task. One quarter's waste, exclusive of old tins and waste-paper, netted £343—$1,715—of which £249—$1,245—was obtained from rags alone. There were 264 dozen jam-jars collected. They cost 15s. —$3.75—a gross new, and the trade expressed its readiness to take over the reclaimed vessels at 7s. 6d.—$1.87 —a gross. Kensington made £1,000—$5,000—from the sale of one year's collection of waste-paper. The Southport authorities recovered £2,000—$10,000—over a similar transaction. The metropolitan boroughs of Finsbury and Marylebone each swelled its local treasury to the extent of £500—$2,500—in a similar manner. The City of London garners 30 tons of this commodity every week. The ink-bottles recovered from the garbage barrels of the metropolis would provide a person with a comfortable income, averaging as they do several gross a day. Liverpool derives £300 —$1,500—from house-swill alone, which it collects, dries, and turns into poultry-meal to sell at £15—$75—a ton. Aberdeen, as the result of one day's organized collection, secured sufficient bottles to realize £567—$2,835.

It is obvious that, no matter from what point of view the question is regarded, systematic organized salvage of the contents of the household dust-bin can be rendered a highly profitable enterprise. Certainly it opens up a promisingly rich and legitimate field for municipal trading, though it is equally accessible to private initiative. It is only requisite to survey the whole situation of the disposal of house garbage from the new angle of scientific application.

It is not refuse in the generally accepted interpretation of the term. Such material should rightly be regarded as by-products of the private domestic kitchen.

The tardy recognition of this fact is responsible for a curious reversion in practice. The open-air sifting of house refuse for the recovery of substances possessed of commercial value was unequivocably condemned from health motives, as previously mentioned. Yet, in order to recover these articles, some system of selection and hand manipulation are inevitable, notwithstanding the high degree of intellectuality to which machinery has been advanced. But the old system of hand-picking was primitive in its simplicity. The circumstance that household refuse, both organic and inorganic, possesses virtues which the vogue of the destructor caused to be blindly ignored, has been responsible for a manifestation of marked ingenuity upon the part of the engineering profession. The necessity to recover every ounce of material possessing a market value was never so acute as it is to-day. Supplies are short and are likely to remain inadequate for some time to come, while the high level of prices is apt to compel more rigid economy. Yet the strains encountered in this direction may be very sensibly lessened by the practice of salvage along more intensive lines.

It would seem as if refuse recovery were destined to develop into a highly specialized branch of the engineering craft. Hitherto for the most part the engineer has confined his efforts towards garbage-disposal by destruction, but the new tendency is far more logical and deserving of every encouragement. Certainly it is a field in which abundant scope is offered for brilliancy and ingenuity of thought. This is demonstrated by the activity of certain firms, more particularly of one in the North of England, the guiding hand of the destinies of which has evolved a complete recovery plant, having many decidedly ingenious features, and which is already being installed by certain of our more progressive corporations and municipal authorities.

This plant is self-contained, and, so far as is feasible, is automatically operated. While hand-picking cannot be entirely eliminated it has been reduced to the minimum. The system adopted facilitates the task, and renders hand-picking as congenial as the peculiar conditions will permit.

Furthermore it is an individual entity. While it can be established in an isolated centre it can also be coupled up to the existing dust-destructor, or power-generating station if preferred, thereby complying with the general desire to centralize municipally-controlled installations. This is certainly a powerful recommendation, because it avoids superfluous transport and handling.

Under this scheme the refuse-collecting vehicles discharge their loads into a receiving hopper from which the material falls by gravitation into a hexagonally-shaped revolving riddle. This screen or reel for two-thirds of its length is perforated to allow the fine ash associated with the waste to escape into another large hopper placed immediately beneath. The ash may then either be withdrawn directly from this hopper into wagons or carts for removal, or should arrangements be made for its combination with other ingredients to produce a fertilizing agent, it may be led by conveyor from the hopper to the compounding-room.

For the remaining third of its length the hexagonal revolving screen is perforated with a coarser mesh to permit the cinders to escape into a separate hopper, at the base of which is a worm conveyor which receives the cinders and bears them to a washer. The washing operation is introduced to allow the separation of the light or combustible fuel—cinders—from the heavier clinker, fragments of glass, pottery, and other incombustible substances. At the same time all fine dust clogging the interstices or pores of the cinders is removed, thereby facilitating the subsequent combustion of the cinder, while, of course, the heat produced from the cleansed fuel is greater than that derived from such material loaded with incombustible dust.

After being washed the cinders are picked up by a scraper elevator. If it be intended to utilize this fuel for raising steam in the adjacent power plant it can be carried by conveyor direct to the boiler-room, to be discharged into the bunkers or furnaces. Should it be decided to dispose of the cinders, either wholly or in part, to the general public, they may be taken by the transporter to any suitable point to be stored against sale in bulk or in bags.

A second scraper elevator gathers the heavier debris separated from the combustible fuel in the washer, and

carries it to a pulverizer, to which it is delivered through a chute. If the fine dust associated with the raw refuse, and which fell through the receiving screen, be not delivered from its hopper into vehicles for immediate disposal, it may be led to this point to be stored in the pit receiving the material from the pulverizer with which it may be mixed. Of course, the dust is not passed through the grinding plant.

The elimination of the dust and coarser material from the crude garbage in the receiving screen leaves an appreciable quantity of organic and inorganic matter, comprising such divers substances as paper, fragments of wood, bottles, jars, bones, tins, and vegetable material to be handled. As these cannot pass through the perforations in the sifting screen they are delivered on to a broad endless conveyor-belt travelling between two platforms. This is the "picking belt," from the fact that as the material is borne along between the two platforms the useful material is removed by the hands of pickers, to be cast into suitably disposed bins. In this manner the process of segregation is carried out with the minimum of effort, while the material is in movement, and under the most congenial conditions the character of the work will permit. It represents the only stage at which recourse to manual labour is required, so that it will be seen that hand-selection is reduced to the absolute minimum.

The waste-paper is not touched by hand. At a suitable point a specialy designed hood, connected to an exhauster, is mounted over the picking belt. When this is set in motion the induced draught is sufficiently powerful to suck up the paper, and to bear it through a special conduit to be discharged into a convenient receptacle, whence it may be removed to the baling press.

This plant, known as the Hoyle refuse-recovery installation, after its inventor and designer, Mr. H. P. Hoyle, is extremely efficient. Simplicity is the outstanding feature, while its operation is economical and requires only the minimum of labour. So far as power is concerned a single 10 horse-power electric motor suffices for all operations. The capital cost has also been kept down, the price of the complete plant being from £1,500 to £2,000—$7,500 to $10,000.

At this figure the installation of the system should prove distinctly profitable, more especially in conjunction with one or two auxiliary appliances which offer the means to enhance the market value of the recovered materials, although they are not essential. For instance, an appreciable proportion of the tins thrown into the dust-bin are in a bright condition and free from rust. Such tins can be made to yield so much crude tin plate for the production of further tins, instead of being subjected to the less economic process of crushing, baling, and detinning or transference to the furnaces in billet form to be melted down.

A special type of machine has been evolved whereby the tops and bottoms of the bright recovered tins can be cut off. The resultant cylinder is then cut through on either side of the original seam, and the sheet pressed out to form a flat plate. The eliminated joint, of course, is set on one side to be treated for the recovery of the solder, while the small pieces of tin find their way to the scrap-metal bin. The sheets of bright tin which are thus recovered, and which are quite equal to new tin-plate, command a ready sale, because they can be restamped into smaller flat tins for packing boot polishes and similar commodities extensively retailed in this form. The process is simple, rapid, and can be made profitable.

Rusted tins require to be treated in a different manner. Some corporations merely crush them flat to facilitate and to cheapen transport, selling them in bulk to firms who specialize in the handling of such product. However, it is a matter for investigation, when such tins are recoverable from the garbage in appreciable quantities, as to whether it would not prove more remunerative to the local authorities to deal with the tins themselves. A furnace is required to burn off the tin-dirt and to recover the solder. The tin itself, representing about 1 per cent., is lost, although there are processes in operation for its reclamation. The receptacles may then be crushed and baled into billets for which an hydraulic press is necessary. A plant capable of making a bale measuring 24×14×6 inches is well-adapted to this duty. The solder is in demand, while the plate is worth from £3—$15—upwards per ton as scrap metal. At this figure the local authorities would undoubtedly find it far more profitable to incur the extra expense and labour involved

to prepare the billets rather than to dispose of the tins in their crude form. When the quantity is heavy direct sale to the steel-works is possible and the middleman's profit diverted to the benefit of the ratepayers.

Paper should also be baled for reasons of transport. Either hand or power appliances may be used, but unless the quantity likely to be handled is pronounced, the hand-operated machine will be found adequate for the task. Of course, it must be admitted that, to-day, prices for the recovered materials rule somewhat high. Consequently it may be averred by critics that, whereas such auxiliaries might be perfectly justifiable under conditions such as now prevail, they would fail to show an equally satisfactory result in normal circumstances.

But it must not be forgotten that prices are steadily rising all round. Accepted raw materials are costing more, labour is more expensive, and the tendency in both directions is still in the ascendant. But even should prices and costs droop, it must not be forgotten that such a movement would be attended by the utilization of greater quantities of the articles concerned. They would be recoverable from the garbage in greater volume, and then it would be possible to keep the plants running to their full capacities for no heavier operative or overhead costs. Consequently, in the long run the disposal of enhanced quantities of tins, either as "bright" or scrap, at a lower figure, would probably prove more profitable in the aggregate than treating a limited supply, such as obtains under stringent economic conditions, at a high figure.

How does a recovery plant of the foregoing description work out in practice? This is the vital question. Upon this point it is possible to advance some interesting figures. An investigation of the domestic refuse problem as it affects the country as a whole has revealed the circumstance of the contents of the dust-bin being tolerably consistent, whether it be drawn from a residential or manufacturing town, from the East-end or from the West-end, from the city or from the suburb. On the basis of the analysis set forth elsewhere in this chapter, and taking for our illustration a metropolitan suburb having a population of 85,000 souls contributing 100 tons of refuse a day, the possible recovery of by-products comes out as follows :—

Material.	Tons per Day.	Price per Ton.		Total Value.	
		£ s. d.	$	£ s. d.	$
Fertilizer prepared from fine dust and pulverized debris from washer and picking belt	65	0 1 0	0.25	3 5 0	16.25
Cinders	25	0 10 0	2.50	12 10 0	62.50
Tins and metal ..	2	4 0 0	20.00	8 0 0	40.00
Paper (unsorted, dirty)	1	7 0 0	35.00	7 0 0	35.00
Rags	0·5	15 0 0	75.00	7 10 0	37.50
Glass	0·5	2 0 0	10.00	1 0 0	5.00
Gross total per day				£39 5 0	$196.25

The foregoing figures may be accepted as moderate. Thus the cinders, with a heating value equal to five-sevenths of that of good steam coal, are priced at 10s.—$2.50—per ton. But, as experience has proved, they readily command 14s.—$3.50—per ton, providing, in their washed condition, a first-class, clean, cheap and economical fuel for the poorer classes of the community. At 10s.—$2.50—per ton they are equal to coal costing 14s.—$3.50—per ton, at which price such fuel is absolutely impossible to-day. Even coke cannot be purchased at double the figure. In other words, by buying washed cinders at the prices quoted the purchaser is receiving a fuel equal, if not superior, to contemporary household coal costing 35s. to 50s.—$7 to $10—per ton.

Again, the tins are assessed at a low scrap-metal value. Probably 50 per cent. of the tins rescued from the dust-bin to-day coincide with the term "bright," and thus would pay to turn into tin-plate. The quotation for this material ignores the value of the solder, as well as that ruling for other metals, such as brass and copper, and of which far more is recovered from the ash-barrel than may be popularly imagined. The figure given, moreover, represents the official price, but since the removal of control scrap-metal has recorded higher quotations. So far as the other materials are concerned the prices may be taken as representative.

On the above showing of £39 5s.—$196.25—per day

the plant gives a gross return, in round figures, of £235—$1,175—for a six-day week, or £11,775—$58,875—for a 300-day year. Allowing £5,000—$25,000—a liberal figure—for the annual operation of the plant, the sum of £6,775—$33,875—remains—the net return from the realization of some of the utilitarian material recovered from the dust-bins into which 85,000 people throw what they consider to be useless during the course of the year. Truly may it be said that the average member of the public has but little, if any, idea of the wealth he allows to slip through his hands as a result of carelessness or lack of knowledge. Again, when it is reflected that, for the most part, the whole of such potential wealth as this has been permitted to vanish in smoke, or if incombustible to be kicked from pillar to post, we certainly cannot complain when accused of deplorable extravagance.

So far as the capital expenditure of a plant, such as is set forth above, is concerned, this may be set down at £1,000 to £1,500—$5,000 to $7,500. If for such a paltry expenditure a net revenue of £6,775—$33,875—can be secured during the course of the year, surely the moment has arrived when we ought to put our civic and municipal houses in order. Granting that prices to-day are abnormal, and reducing the net return by 50 per cent., even at £3,387—$16,935—per annum, which may be taken as a safe assumption, a plant of this description is able to pay its way within a short time after its installation, after making even the most liberal allowances for capital charges, interest, and depreciation.

The Hoyle system is one which should make a powerful appeal to the small communities, which, at the moment, are deficient in any system of garbage disposal other than open dumping. It has the governing virtue of being extremely flexible, being as readily applicable to the small town, numbering only a few thousand—even hundreds—of inhabitants as to the teeming city of a million or more souls. The financial outlay involved is comparatively trivial for the results achieved, and varies according to the size, capacity, and completeness of the plant.

Should our smaller towns embrace the system the contributions to the searching problems of the moment would, in the aggregate, be decidedly startling. The materials thus recovered, turned into the proper channels, would go

a long way towards relieving the strains which are being experienced. The small town has a golden opportunity to demonstrate to the larger communities how things should be done. For the most part it is not saddled with a costly, so-called hygienic, destructor. The science of turning the contents of the dust-bin to commercial advantage is one offering possibilities too numerous to mention and might even lead to the establishment of local industries. Nothing organic or inorganic possessed of any utilitarian value need be lost.

On the other hand the city is not in such a fortunate position. It will have to forget a good deal of what it has assimilated in connection with the disposal of the contents of the ash-barrel. A change-over from the old to the new method must inevitably occupy time, especially as those two dragging chains which always retard the march of progress—prejudice and conservatism—have first to be released. Nevertheless, as destruction of domestic waste by fire superseded dumping upon open land, so must incineration, in turn, give way to the latest demands of science and the immutable economic law. The dust destructor never could possibly be construed into a scientific solution of the problem: it has no constructional or creative value, except of a nuisance in the form of accumulations of clinker. Even primitive dumping upon the land did possess the distinct advantage of benefiting the soil over which it was distributed. When the latest idea for recovering and exploiting the by-products of the dust-bin achieves the vogue which it deserves, land and industry will profit to the benefit of the community and of the country.

Naturally, certain local authorities, notoriously opposed to progressive development, will seek to stop the tide by belittling the new policy. They have become so firmly wedded to the destructor in which so much of the ratepayers' money has been sunk as to be blind to improvement. They will continue still to waste money in supporting their fetish, strenuously declining to honour the axiom that it is often cheaper to cut the loss.

In the absence of willingness to jettison the old and to adopt the new, the pressure of compulsion should be applied. Local authorities must be prevented from continuing to squander potential resources of raw material. Alternatively,

the exploitation of the despised dust-bin should be brought within the reach of private enterprise, which should be extended every encouragement. Other nations have always regarded our much-vaunted dust destructor as the high-road to waste. It has never found any pronounced favour beyond the confines of Britain. Have our rivals been wiser than we?

An interesting commentary upon this somewhat inexplicable predisposition to destruction by fire is offered by the experience of the city of San Francisco. In 1896 the city granted a fifty years' franchise for the provision of a destructor for the disposal of household refuse to a private party. "This destructor," remarks the city engineer in a communication to myself, "is the second, and last, example of the Thackery furnace and arrangement, the first having been built in Montreal, Canada, the previous year (1895)."

This plant has passed through somewhat strange vicissitudes. In 1910 it was purchased, together with the franchise, by the city authorities for £70,000—$350,000. It was then leased to a private party, under privilege, in return for an annual payment of £3,700—$18,500—5 per cent. upon the purchase price. During the early months of 1918, owing to the great increase in wages and other costs of operation, the lessee relinquished his lease, so that it was thrown back upon the hands of the city authorities. It was then taken in hand by the Scavengers' Association under permit from the city, by whom it is at present being run at a cost of about 4s.—$1—a ton for the 375 to 380 tons of refuse collected daily by the scavengers.

But the city authorities are not impressed with this method of disposing of the contents of the ash-barrels of its citizens. "During the past year or two," continues the city engineer in the communication already quoted, "we have become more than ever impressed with the wrong of unnecessary waste and have been making special study of our conditions and the means of improving them. Ordinances for segregation at the source, and collection of all, both garbage and rubbish, are now under action by the Board of Supervisors—the governing body of the city—and specifications are being prepared and bids asked upon the same for the collection and disposal of garbage and rubbish.

"It is specially provided that all proposals shall be based on a recognition of the need of conservation and the recovery of all values to the point of balance between profit and loss. It is expected that the garbage from households will amount to upwards of 100 tons daily, and that it will be attractive to hog-raisers."

CHAPTER X

LIVING ON WASTE

WAR is Hell. So said Sherman, and it is a verdict with which the whole world will agree. But war is also a powerful educating force. If any convincing testimony upon this point were required we have only to reflect upon the effective manner in which the recent European conflagration caused the British nation to revise its methods and practices. The stress of war, ravages by submarines, depletion of transport facilities by sea, road, and rail, and the shortage of crops and labour, compelled the community to consider the food question in a light totally different from that with which it was regarded during the days of cheapness and plenty. We were forced to digest lessons which under normal conditions we would have ignored in contempt. Whether the changes wrought in our complex social and commercial life are destined to be permanent in character is another question, but the continuation of high prices is tending to consummate this end, the process being assisted by the reflection that the good old days are destined never to return, at least not for many years to come.

In the previous chapter I have recounted how the engineer is now striving to conserve rather than to destroy what we throw to one side as of no further use. By inventive ingenuity he is endeavouring to bring home to our local authorities how to extract further utilitarian value from what the household discards. The question immediately arises as to what extent this tendency towards preservation and construction, as opposed to destruction and loss, is being supported in a practical manner by the authorities concerned.

It is to be feared that, considered on the whole, the seeds which are being sown are falling on barren ground. How-

ever, here and there our civic and municipal authorities, especially those who evince a distinct pride in being numbered among the pioneers of progress, are fully alive to the possibilities of the problem, and are leaving no stone unturned, nor sparing any exertion, to bring home to the public at large that refuse is merely matter in the wrong place. In some instances this reversion to rigid economical methods is not of modern record, the practice of salvage or recovery of abandoned products having been practised along more or less comprehensive lines, as indicated by scientific thought, for many years past.

The city of Glasgow is able to point to a convincing record of what can be achieved in this direction. In the years 1908–9 the fathers of the progressive Scottish city derived £41,000—$205,000—from this source, while during the ten years ending 1918 what is commonly regarded as rubbish and useless has been induced to yield no less than £50,300 —$251,500. Surely what can be achieved in one city is equally possible of attainment in every other community throughout the British Isles to a greater or lesser degree!

Glasgow has evolved its own organization for retrieving and utilising the city refuse and in accordance with the conditions which obtain in the locality. Speaking generally, the system may be described as one of separating the saleable from the unsaleable. Previous to the year 1917 efforts were devoted mainly to the preparation of fertiliser from the contents of the domestic dust-bin, as well as the recovery of tins, but, owing to the high prices which other so-called waste was commanding, and in deference to the national appeal towards greater economy, the reclamation of other materials was taken in hand with highly gratifying results.

The refuse of the city is collected in the usual manner and conveyed to the depot. It is weighed upon receipt. It is then dispatched up an inclined roadway to a tipping floor, where the vehicles discharge their loads through shoots. Beneath the latter are disposed horizontal revolving riddles of conical form. The fine refuse and cinders escape through the grids, but the bulky material is carried forward to be ejected on to a travelling conveyor.

The ashes and cinders which fall through the open mesh of the first riddles are caught by a second and stationary screen. The mesh of this sieve being finer only allows the

dust to escape to fall into a mixing machine. Here it is combined with a regulated quantity of excrementitious matter drawn from an overhead tank. The materials are thoroughly blended, and the mixture ultimately falls direct into railway wagons. In this way all intermediate handling is obviated. This material constitutes a first-class fertilizing agent, is keenly sought by farmers, and accordingly meets with a ready sale.

The cinders, arrested by the secondary stationary screen, are collected in a similar manner. They are not sold, but dumped into the bunkers of the works to fire the boilers, thereby assisting materially in the generation of the power necessary to drive the plant.

The bulkier material remaining in the revolving conical grid is discharged on to a conveyor. While being moved forward all material of value, such as waste-paper, tins, scrap-metal, waste-food, rags, bones, glass and so on are picked off by hand to be thrown into bins. The manual labour employed to carry out this task of segregation may be considered to be an adverse cost factor. But against this expenditure for separation by hand must be set that formerly entailed in the destruction or other disposal of this material. Accordingly, all things considered, it may be accepted that the revenue derived from this source virtually represents money saved.

In addition to the recovery of paper from the above-mentioned refuse the Cleansing Department also maintains a special service for the collection of such waste from offices, warehouses, and private residences throughout the city area. This procedure has been in operation for many years, but, owing to the scarcity of paper encountered during the war, and the need which consequently arose to display accentuated enterprise in this direction, an auxiliary collecting service was inaugurated. It was conducted by the members of the Women's Volunteer Reserve, who received a percentage of the profits arising from the sale of the waste-paper thus gathered.

So far as the waste-metal—light scrap, tins, and other odds and ends of a metallic nature—is concerned this was formerly sold in the form of detinned compressed billets. Under the present contract this is delivered to the contractor in the condition in which it is received. But it is quite

possible that, at some future date, there may be a reversion to the baling process which formerly obtained. In view of this fact it has been deemed advisable to bale a certain proportion of the recovered metal merely in order to maintain the hydraulic compressing plant in good working conditions. The practice is to separate and to classify metallic material under one or other of six headings—bright tins, galvanized metal, light iron (black), cast iron, enamelled ware, and burned tins respectively.

While the Cleansing Department hitherto has not devoted any attention to the recovery of garbage from the refuse for conversion into pig-food, it is possible that this issue may be undertaken at a future date. The authorities have the suggestion under serious consideration with a view to its adoption.

The clinker question commands the attention of the Glasgow authorities, as it does all other communities equipped with facilities for carrying out refuse destruction by incineration. But, so far as this city is concerned, the problem does not bristle with perplexity as is invariably the case. The residuum from the furnaces of the Corporation works is mechanically screened into five varying grades, to meet the requirements of contractors who find it eminently adapted to their particular needs. No difficulty has yet been experienced in regard to the disposal of this article, a ready sale always having prevailed for the stocks available.

That the reclamation of the utilitarian contents of the domestic dust-bin is distinctly remunerative to the Glasgow civic authorities is reflected from a perusal of the revenue derived from the recovery and disposal of the city's refuse during the year ended May 31, 1918. The sales' record is as follows :—

Materials.	£ s. d.	$
Waste-paper	8,993 14 5	44,969
Old tins, light iron, etc.	2,684 17 9	13,425
Clinker	718 10 10	3,592
Sundries	72 14 5	363
Total	£12,469 17 5	$62,349

To the above total there remains to be added the revenue derived from the sale of the prepared manure, arising from the admixture of the finely-screened dust and excremental material. This realized £6,718 17s. 8d.—$33,594—bringing the grand total to £19,188 15s. 1d.—$95,943. In this return the cinders are totally ignored, but, seeing that they constitute a highly serviceable fuel, the saving in the coal-bill, which their use secured, should be taken into consideration.

It is necessary to explain that, inasmuch as the thorough separation of the material is only of recent date, previous operations having been confined to the recovery of paper, old metal and the preparation of the fertilizer as already mentioned, the item " Sundries " cannot extend any criterion as to the results now being recorded, nor of the revenue derived from the recovery and disposal of the additional articles.

The successful conversion of the volume of dust, comprising about 50 per cent. of the aggregate, into a marketable fertiliser, offers a satisfactory solution of a complex and perplexing problem. But when the dust is coarser and yet deficient in " bite " or gritty characteristic, its disposal is not so readily consummated because its possible applications are thereby severely narrowed down in number.

Speaking generally, the utilization of the fine dust may be said to present a vexatious question. While it forms an excellent ingredient for a compounded fertilizer, it is not a simple matter to discover an inexpensive, and preferably second, refuse constituent of approved manurial value with which to associate it. The majority of the ingredients advocated as complying with the desired requirement possess too high an independent fertilizing value for such an application. In itself the dust is of very low soil-feeding power, and so active investigation is being pursued in anticipation of the discovery of a satisfactory adjustment to this question.

Another enterprising illustration of what can be achieved with domestic, office and warehouse refuse, both organic and inorganic, is extended by the Port of Liverpool. Here, again, the developments to be recorded in this connection are not attributable to the war, although the last-named factor was responsible for the conduct of the reclamatory process upon a more intensive scale. Liverpool is somewhat

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peculiarly situate among the importing centres of the United Kingdom seeing that it is probably the largest distributing centre for American foodstuffs for this country. Consequently, as is only to be expected, very considerable quantities of food which have suffered such damage during transit or demurrage as to become unfit for human consumption have to be handled. Under the old *régime* all organic waste of this character was either consigned right away to the destructor, or was perfunctorially treated to be sold as manure. Neither science nor brains was displayed in its disposal. The shortest way out of the difficulty was accepted as being the most effective in the public interests. But Liverpool was not the only port to follow such summary practice. It was common to all ports of the country in greater or lesser degree. The public loses heavily from the observance of such deprecatory measures, especially when it is borne in mind that such traffic runs into tens of thousands of tons during the course of the year. But under pre-war conditions, owing to the plentitude of supplies and the wide distribution of the losses incurred, the financial effect was scarcely felt by the unit of the population.

During the war a loud wail went up because a number of hams and a quantity of bacon had been found in a decomposed condition at a certain port. Had this occurred during pre-war days not a word would have found its way into the public press, and the destructor alone would have known of the incident. But because under war conditions the public was directly affected—was clamouring for this particular article of food—the wastage was declared to be intolerable. Fortunately, in this instance, owing to our having become more enlightened, the spoiled food was not totally lost. The fat was reclaimed, while the residue was turned to its most profitable account.

At Liverpool, as at other centres where a vigilant eye is maintained upon the clock of progress, it was speedily discovered that the methods of handling such refuse were distinctly deprecatory. It was decided to introduce improved practice. One material was treated as an experiment, and the process was found to be profitable. Gradually other condemned articles of food were taken in hand. This logical development of salvage was continued, until to-day there

is very little material entering into the composition of the Liverpool dust-bin which does not find some one or other useful application.

It was learned from studied investigation that waste-food products collected with the refuse of the city might be classified into five broad divisions, namely butchers' and fishmongers' offal, damaged fruit and vegetables, damaged eggs, damaged canned foods, such as meat, fish, milk and so forth, as well as warehouse sweepings. Over and above this assortment, of course, came the miscellany to be found in every ash-bin drawn from the home. To ensure the receipt of the offal from tradesmen a special and separate collection from all retail shops dealing in fish and greengrocery was inaugurated. Subsequently, to prevent the wastage of swill suitable for the sustenance of pigs, a special collection from private houses was introduced.

In every city the isolation of the swill from the general material consigned to the dust-bin though freely urged is a somewhat difficult issue to carry into practice. Segregation at the source is imperative to ensure the maximum results being attained. But the Liverpool authorities overcome the obstacle very satisfactorily. The residents were notified of the intention of the department charged with this duty, while officials were detailed to visit and to explain to residents the proposals, and to extend advice upon what, and what should not, be thrown into the dust-bin. Moreover, the City Fathers undertook to provide each house with a special receptacle for the swill, and to collect it at frequent intervals. Experience proved that collection twice a week sufficed to meet every requirement.

But, as a rule, when the suggestion is made that local authorities should provide special receptacles for swill, demur is made on the plea that such a procedure must entail further capital expenditure. Yet it can be carried out along very inexpensive lines if attacked in the proper spirit. So far as Liverpool has been concerned it was even found possible to turn a waste article to such account. Among the flotsam and jetsam sent to the corporation depots for disposal were thousands of tins measuring 9×9×13 inches, originally used for the conveyance of oil to this country. Examination revealed the circumstance that these discarded receptacles could readily be converted into swill-pails, their dimensions

and construction admirably adapting them to such a duty. Forthwith they were cleaned, one or two minor alterations carried out, and then painted. The cost of adaptation was less than 1s.—25 cents—per tin. These were then issued to the residents who expressed readiness to co-operate with the efforts of the authorities, and proved a complete success. It has often been advanced by local authorities that the residents will never collaborate in such schemes of segregation at the source, declining to be bothered, but the experience gained at Liverpool does not support such a contention. The inhabitants of the city astride the Mersey responded very promptly to the request to save and segregate their swill, the result being that enormous accumulations of potential and valuable pig-food were secured.

Swill supplies being assured, the next step was to handle this waste at the depot, and to prepare it for the piggeries. The City Engineer, Mr John A. Brodie, M.Inst.C.E., advanced a complete solution to this problem and along economical lines. A number of old pitch boilers and other plant was lying idle at the depot. This was turned out, overhauled, rigged up and coupled up to the steam generating equipment of the destructor. The household swill was cooked in these vessels, and in this manner a first-class pig-food was produced. To ensure the consumption of the swill thus obtained the Corporation installed its own piggeries and poultry runs upon its farms. The swill, while still hot, was conveyed to the piggeries in the municipal motor wagons and doled out. Private pig-raisers were also at liberty to obtain the swill in the heated condition if they cared to fetch it. This facility was readily accepted, inasmuch as it saved the pig-keepers the trouble and time of conducting collection from houses in the conventional manner and then boiling it upon their farms for their animals.

Continuous development of the reclamation of waste problem has been the policy of the Liverpool civic authorities. Satisfied with the pecuniary and other results attending their initial efforts the City Engineer installed an inexpensive and complete plant working upon the Scott system, described in another chapter, for the full reclamation of the material contained in the city refuse. It was laid down at the central depot primarily to treat the meat, fish, and other organic offal, increasing quantities of which were forthcoming. The

plant in question comprises a digester, dryer, vacuum pump, disintegrator and fat tanks. Electric drive is employed throughout, the necessary power being drawn from the municipal generating station.

The digester, made of steel, 7 feet long by 3 feet in diameter, is of sufficient capacity to receive one ton of refuse at a time, and works at a pressure of 60 lb. It is charged from the top and emptied from the bottom. It works upon the jacket principle, and the necessary steam may be admitted both at the top and bottom as desired. Top and bottom cocks are fitted for drawing off all fatty and oily liquid for the fat tanks, and also to draw off the liquor. About four hours are required to treat the charge.

The vacuum dryer is a drum, 4 feet 6 inches deep by 5 feet in diameter, and is also able to receive a charge of one ton. Top and bottom facilities, for charging and emptying respectively, are provided. Within the vessel rotating blades are disposed to keep the contents in agitation during treatment, these blades making about 25 revolutions per minute. All foul gases arising during the process are drawn off by a vacuum pump, and are led to the furnaces to be consumed, thereby being rendered innocuous before escaping into the atmosphere.

The disintegrater is a cast-iron cylinder provided with a continuous automatic feed. Within the vessel are set a number of steel arms which run at a very high speed—about 2,500 revolutions per minute—which break up and thoroughly disintegrate the refuse introduced until it is able to pass through the meshes of the screen placed at the bottom of the machine.

The process is very simple. The refuse is dumped into the digester which, upon being filled, is sealed. Steam is turned on, and the resultant cooking releases all the oleaginous constituents of the contents, which are floated off through the cock to be led to the fat-recovery tanks. The cooking is continued until the raw waste has shed every drop of recoverable oil and grease. The digester is then emptied, pressed, and the cooked material passed to the dryer to be dried, thence to the disintegrator to be pulverized or ground to the required degree of fineness.

The fatty and oil liquors drawn from the digester fall into a tank, and the fat and grease collecting on the surface

are skimmed off to be passed to a lower tank. All tanks are kept at a certain degree of temperature by means of a steam-heated coil. The fat and oil reclaimed in this manner are subsequently treated for their yield of glycerine, the final residue entering into the preparation of soap and other articles.

The solid residues recovered from the disintegrator, representing the fibres from the meat, fish offal and other solid matter, constitute an excellent poultry food. According to the analyses which have been made it is rich in the albuminoids and phosphates.

While the foregoing naturally represents the foremost and greatest phase of salvage activity pursued by the Liverpool Corporation it by no means exhausts their efforts in this direction. Other refuse is recovered and treated for some one or other specific commercial purpose. All bones are collected, washed, and boiled to secure the fat, the solid matter afterwards being ground into meal. Vegetable refuse, of which large quantities are forthcoming, especially from the markets, are dried and stored, having been found useful as a constituent for poultry foods. Fish, both offal and unsold inedible surplus,is converted directly into fertilizer. Wooden refuse, recovered from dust-bins and other sources, is heated at low temperature to allow carbonization for sale as charcoal. Large quantities of straw, both clean and soiled, are also brought in, being recovered from packing-cases and crates. The clean straw is segregated to be chopped finely, and as such meets with a ready sale among poultry-raisers because it constitutes a very effective scratching material. The dirty straw, together with soiled paper and old wooden boxes incapable of other treatment, as well as other light refuse, are burned in a special furnace which has been installed, care being observed to collect the ash. As the latter contains approximately 12 per cent. potash it forms a first-class fertilizer. Banana stalks are likewise rich in potash, and so, by submitting the stalks, large quantities of which are forthcoming from the fruit markets under normal conditions, to a special treatment, this potash is recovered and is turned over to the soap-makers. Oyster shells are washed, calcined, and then ground for sale as grit to poultry-raisers.

Damaged and condemned eggs are frequently received in large quantities from the docks, warehouses and wholesale

establishments. One consignment numbered no fewer than a quarter of a million. Instead of being used as fuel for the destructor, these eggs are boiled, then chopped, dried and together with the shells are finely ground into meal for use as chicken food.

Consignments of ham and bacon are often received in heavy quantities at times from the docks. This inedible food is submitted to treatment to secure the various commercial by-products such as oil and grease, the residue being ground up into meal.

From the foregoing it will be realized that Liverpool is not permitting much waste of any commercial character to find its way to the incinerator. The wise policy now being pursued is bearing fruit. The prices which have been, and still are being, realized, render the trouble and effort expended well worth while. The meal made from fish offal, after the extraction of the oil, has fetched as much as £25—$125—per ton, while the butchers' offal, after similar treatment, has commanded an equally satisfactory price. Even the refuse gathered from the households of the city, and capable of being turned into poultry-meal, which exceeds 20 tons a week, is promptly sold at prices ranging up to £15—$75—per ton. The possibilities attending systematic collection from private residences have also been conclusively established, and at the moment the Corporation is gathering a round 1,000 tons of such waste from certain houses in the course of the year. Reclaimed tins, after being washed and dried, have realized up to £8—$40—per ton, while, to meet the enhanced request for organic manure, an excellent fertilizer is being prepared from certain materials which come into the hands of the authorities, or accrue from the practice of waste-reclaiming. The Corporation are able to dispose of this fertilizer with comparative ease at the rate of 50,000 tons during the year.

Other towns are able to point to comparable achievements in connection with the exploitation of waste incurred within their areas. Some of the small communities are even able to produce some startling records in this connection. If all our civic and municipal authorities could be brought into line and raised to the productive level of Glasgow or Liverpool, the cumulative benefits to the nation would be enormous and far reaching. But, as yet, only a fraction

of what might be secured is being turned to useful account. For instance, it is computed that 3,000 tons of first-class pig-food could be recovered from London alone every week—this in itself would show a heavy yield of fats and greases if properly treated—but at present it is being wasted.

Merely because foodstuffs—meat, fish, eggs, fruit, and other commodities innumerable of a perishable nature—are condemned as being unfit for the service of man, that is not to say they have completed their mission in the scheme of things ordained by a so-called high civilization. Doubtless they assist in the manufacture of excellent paving-stones, but although we are in dire need of houses and this is the concrete age, that is not a sufficiently reasonable excuse for withdrawing nitrogenous products from the cycle of Nature.

CHAPTER XI

POTATO WASTE AS AN ASSET TO INDUSTRY

The potato has entered so intimately into our domestic life as to be regarded as indispensable to the human dietary. Whether its food value be exaggerated or otherwise, the fact remains that, speaking generally, it now ranks second to wheat in the estimation of the bread-eating nations. A potato-less dinner-table would create more dismay than one from which the familiar roll is missing, while some of us may even recall the widespread misery which was provoked in Ireland during the black years of 1845 and 1846 from the failure of the potato crop. The succulent tuber has achieved such a high estate among the community as to be deemed capable of taking the place of the cereal associated with the staff of life should exigencies so demand.

In view of such extreme popularity it is not surprising to find the potato cultivated extensively in the British Islands to serve essentially as a foodstuff for both man and beast. No allotment-holder would consider his endeavours to be complete without the inclusion of this vegetable in his gardening programme. As illuminative of the grip which the cult of the potato has secured upon the amateur son of Adam it may be mentioned that the allotment-holders of England and Wales raised a round 1,000,000 tons of this tuber, for the most part upon 10-rod plots, during the year 1918. Many farmers now regard it as the backbone to their agricultural endeavours, especially in those parts of the country where the soil conditions are particularly favourable to its easy and prolific cultivation.

Yet, in our use of the potato, we are extremely wasteful. We lose or discard at least one-third of what we grow. It is estimated that 25 per cent. of the value of a crop is lost

to the farmer in cartage, carriage, clamping, bagging, marketing, and grading. This figure does not take into account the circumstance that only the cream of the crop—the ware potato—is set aside for human consumption, for which, of course, the maximum price is demanded. Neither does it refer to the losses incurred from the ravages of diseases, which, while varying according to the soil and weather conditions, are always material. An appreciable proportion of this loss and waste might be avoided were the practice of storage by clamping superseded by a method more in accordance with contemporary thought.

A further loss, even in connection with those set aside for the table, is incurred in the preparation of the vegetable. Peeling, as a rule, is clumsily and perfunctorily performed, "spud drill" being considered as one of the drudgeries of domestic life, because a pronounced portion of the edible flesh is removed with the skin, eyes and other unsightly or inedible parts. The extent of this loss varies with the size of the tuber and the carelessness or skill of the peeler. Consequently it may vary from 10 to 30 per cent. or even more.

What is done with the peelings? For the most part, notably in towns and cities, they suffer cremation, either at the destructor, via the dust-bin, or in the kitchen stove. But potato-peelings constitute an expensive fuel. The rural resident is generally more thrifty. He throws the peelings into the swill-tub for pig-food, or husbands them to boil and to blend with grain offal to sustain his poultry-run, but the quantity thus turned to economic account is really an insignificant proportion of the whole. Quite 600,000 tons of potato offal are destroyed in ignorance during the year—a deliberate wastage of valuable raw material.

The growers' losses are equally startling, more particularly in clamping. The tubers afflicted with disease meet with instant rejection and destruction. Even the balance of good and sound tubers, remaining after the selection of the ware and seed grades, is utilized along the most wasteful lines, being regarded as fit for cattle only.

The farmer is not to be blamed for such extravagant use of the proportion of his crop which fails to rise to the high standard set for the table. He has not been enlightened

either in regard to the constitution of the potato or its potential industrial uses. Even if he be cognizant of these factors he cannot more profitably exploit his surplus owing to the absence of all facilities to such an end.

Of what is the potato composed? Here is the result of an average analysis:—

	Per cent.
Fat	0·3
Cellulose	1
Mineral matter	1
Dextrine and pectose	2
Fibrin and albumen	2·3
Starch	17
Water	75
Waste	1·4

The term "waste" included in the above table in reality is somewhat misplaced, as I explain later. The starch content is also a variable factor. While one analysis may show a percentage of only 15, another will yield a figure exceeding 18 per cent. Consequently that quoted may be accepted as representative.

Familiarity with the chemical composition of the humble potato prompted the Germans to regard it from two distinct view-points. The one, as in these islands, concerned its food potentialities; the second took into consideration its possible application as a raw material for several industries, such as the manufacture of alcohol, starch, glucose, dextrine, and other articles of commerce. Consequently, potato quotations upon the Teuton markets were dual and distinct. The one price, which was the higher, related to produce intended for the table, while the second, and lower, governed its industrial use.

The provision of two separate markets for the commodity produced the inevitable result. Farmers were assured of lucrative prices for their crop set aside for edible use, while the second market absorbed practically the whole of what was not required to satisfy the first-named demand, and that at an attractive figure. Accordingly, there was every inducement to bring more and more acres under the tuber, which led to the reclamation of poor soils regarded as utterly useless for general agriculture.

But the encouragement thus extended wrought many

other far-reaching benefits. To persuade the poor soils devoted to the culture of the potato to become fertile led to an increased demand for artificial fertilizers, and provided a big domestic outlet for the native potash. The farmers were enlightened as to the many virtues possessed by such manures and were urged to use them liberally. The potash deposits were not the only home resources to enjoy prosperity from such propaganda. The steel industry reaped a certain measure of profit, because the land offered an encouraging market for the enormous accumulations of basic slag arising from the working in steel. Then the alcohol derived from the potato assisted other industries, notably that concerned with the manufacture of coal-tar dyestuffs. From this it will be seen that the increased production of the potato, and its submission to the most economic processes, exercised a repercussive effect in various directions.

It was the pursuit of this policy which enabled Germany to raise 54,000,000 tons of potatoes a year. Of this enormous yield approximately 30,000 tons were used to feed other industries with essential raw materials. The energy displayed by the farmer resulted in the supply exceeding the demand, so it became necessary to devise measures to cope with the glut to avoid the grower, from the receipt of absurdly low prices, being discouraged. The German farmer does not favour clamping: he desires to dispose of his product immediately it is gathered. With such an enormous output this tendency proved an awkward obstacle. The auxiliary industries planned their operations upon a twelve months scale. That is to say, they naturally desired to work steadily the whole year round. The raw material from the soil came to hand in tidal waves, and inconveniently.

The problem of meeting these sudden seasonal surges provoked difficulty and dissatisfaction. The dependent industries acquired their requirements, which left a very large quantity of potatoes upon the growers' hands. They could not hold them through the winter owing to the extreme susceptibility of this vegetable to injury from frost. The merchants were ready to accept delivery and to hold them in store against the calls of commerce, but only at a price which was so low as to leave the growers on the wrong side. The latter, dissatisfied, threatened retaliation in the form

of curtailment of production. At this declaration the alcohol-distilling interests took alarm. To secure themselves against any shortage of raw material they decided to hasten to the farmers' assistance, the merchants being ignored. The Alcohol Association and the Farmers' Societies collaborated to perfect ways and means of saving the surplus both from destruction and the profiteering of the factors. The co-operation of the Government was also sought. The last-named assented to extend tangible aid and forthwith prizes to the value of £1,500—$7,500—were offered to stimulate inventive fertility. As a result of the various discussions it was decided that the most promising solution of the vital question would be to convert the potato into a dried product.

Inventive effort responded very promptly upon the narrowing down of the issue. As a result of searching tests two dehydrating methods were adopted. By these processes the potatoes are washed, cooked, dried, and reduced to a flake and shredded form respectively. The product from the first-named process is described as "flocken" from its flake-like character, while the second is called "schnitzel." The latter is the cheaper process, the cost of dehydrating a ton of potatoes being about 4s.—$1.00—while the conversion of a ton of tubers into flocken costs 10s.—$2.50. However, the capital investment incurred with the machinery for producing schnitzel is higher than that for yielding the flake, and initial outlay being the most compelling feature it is the process which has been most widely adopted. In 1914 there were over 400 factories in operation converting the surplus potato crop into a dried form, of which about 75 per cent. followed the flocken method. But it does not matter which process is employed, the result is the same—the production of a dried potato pulp, capable of being kept indefinitely so long as it is protected against the ravages of damp, and which suffers no injury from frost. From this dehydrated potato it is possible to work up a cheap, excellent cattle-food.

The ability to render the potato into a convenient dry form at a low figure prompted other countries, notably Japan and the United States of America, to resort to similar methods, but to a different end. The potato is rich in carbohydrates, and this fact suggested the subsequent

milling of the dry material into a flour, commercially known as "farina," which has proved a conspicuous commercial success. The demand for this flour is expanding rapidly, because it serves as excellent material for the preparation of bun-flours, cake-flours, custard-powders, soups, and other foodstuffs, designed and marketed with the primary idea of lessening the worries and labours of the housewife.

Previous to the war the price for this imported article varied between £25 and £35—$125 and $175—per ton, the cost of production ranging from £14 to £20—$70 to $100—per ton. The margin of profit was sufficiently wide to warrant the development of the process. Under war conditions the price soared as high as £90—$450—per ton, but subsequently dropped to about £45-£50—$225-$250. A very marked diminution upon this latter figure is improbable, owing to the increased manufacturing costs which now rule.

Therefore the question arises as to whether Britain cannot turn the balance of her potato crop to greater commercial advantage. There is no reason why we should not do so, seeing that in 1913 we imported over 40,000 tons of farina, while in 1917 the value of our importation of this flour rose to £1,040,319—$5,201,595—for about 25,000 tons. It must be conceded, however, that under present conditions less scope exists for such a manifestation of enterprise in this country, seeing that our potato crop is only about one-tenth of what Germany normally raises. But the demand for the by-products in this country is every whit as heavy and sustained as in Germany, while the fact that in this raw material we have the base wherewith to revive an industry—the production of starch—which Germany wrenched from us by unscrupulous trading, alone should be sufficiently attractive to warrant such an attempt being made. Our consumption of starch is heavy, exceeding 50,000 tons a year, while our purchases of dextrine and unpotable methylic-alcohol, both of which can be made from the potato, run into £70,000—$350,000—apiece during the year. Even the industrial alcohol, despite the adverse taxation conditions which prevail, is in urgent demand for many new industries.

If we confine the issue to the farina we have a distinctly promising outlook. British inventive effort has been

encouraged, and has evolved a process and product of this character which are immeasurably superior to those of the foreigner. To us the domestic manufacture of farina is of far wider significance than its mere mention might suggest, inasmuch as it would prove of far-reaching value as an ingredient to the loaf. As a matter of fact the authorities, in their resolve to grapple with the national food question, provisionally ear-marked 2,000,000 tons of the 1918 British potato crop for conversion into farina, to be blended with the domestic wheaten flour, to induce the supplies of the last-named to go farther. The conclusion of hostilities rendered this precautionary measure unnecessary.

In the eyes of many people the addition of potato-flour to wheaten flour for bread may seem reprehensible, and to savour of adulteration. Prejudice is a wellnigh insuperable obstacle to overcome. But in this instance such opposition is misplaced. The introduction of farina to the loaf cannot be regarded as an adulterant, substitute, or even a diluent. Rightly or wrongly, the potato is invested with a high food value: in some quarters it is even held to be an equivalent to the wheat flour. Doubtless opposition would arise from memories of the practice which obtained during the early days of the war. But the faults which were encountered then were due to the method and not to any shortcomings upon the part of the ingredient.

The utilization of the potato for the production of bread is not even a modern innovation. It really represents a revival of a long-since abandoned and wellnigh forgotten art. In the early years of the Victorian era our bakers were compelled to make resort to the potato as a constituent of the loaf. The home-grown wheat physiologically was not adapted to the making of bread, and the same argument applies more or less to the domestically grown cereal of these days. Normally, only a certain volume can be used; it has to be blended with imported flour to obtain the requisite percentage of gluten in which the domestic cereal is deficient. The bakers of a century ago used the potato to obtain the gluten content. With the availability of the more glutinous imported flour recourse to the potato declined, until finally the practice was abandoned.

The revival of the principle to meet the conditions of war proved a failure from the simple fact that the baker

had lost his cunning, and was neither so clean nor so painstaking as his forbears in regard to his utensils and the handling of the tuber. The potato is particularly sensitive to contamination. Should an imperfectly-cleaned utensil be used the resultant bread will speedily sour. Moreover, the mashing of the potato was carried out very indifferently, while its admixture with the other constituents was still more unsatisfactorily fulfilled, with the result that the loaf was a spongy, unattractive, unappetizing, and indigestible mass of doubtful nutritive value.

If the potato be used in the farinaceous form no such objections can be levelled against the ultimate bread. The ingredients can be blended more completely. It is this circumstance which renders the outlook for the potato-flour so promising, and the British process which has been perfected for its production should meet with far more gratifying success.

The preparation of the farina is simple and straightforward. The potatoes are taken in hand immediately after they have been dug, and so are perfectly fresh. They are emptied into hoppers to pass to the washing machine. Then they proceed to the steam-cooker where, unpeeled, they are partially cooked. Finally they are conveyed to the flaking machine, where the first stage of the process is completed. The potato is passed between closely-set, internally-heated rollers, the pulp being rolled out into a continuous sheet about as thick as tissue paper. During this stage the cooking process is completed, while the product is dried and converted into a crisp substance which is peeled from the final roller to fall in a shower of tiny flakes into a trough. It will be observed that the skin, eyes, and other deleterious portions, from which all flesh has fallen away, is collected with the main product.

Cooking, pulping, and flaking expels practically the whole of the 75 per cent. of water entering into the composition of the raw potato. The secret of the process is the control of the temperature, which must be maintained at a critical level, to assure the perfection of the product. If this be excessive there is the risk of the flake becoming charred, while, similarly, should the heat fall below the predetermined point, the product will lack dryness and crispness. As may be imagined, the treatment reduces

the bulk of the potato very perceptibly, 5 tons of potatoes being required to furnish 1 ton of flake.

The second process is of the conventional milling character, the flake being ground to an extremely fine consistency. During this process the skin and all other inedible portions are removed. It may be mentioned that by turning the tubers into flake, slightly diseased potatoes, which would be useless for the table, or which could only be wastefully adapted to such a purpose, may be used without imperilling the purity of the product in any way, and with the minimum of loss. The flaking process presents an absolutely sterilized flour, the diseased portions being removed during milling.

All offal is carefully collected to be treated separately. It has pronounced food value for cattle, and, consequently, is converted into a meal. The production of 1 ton of farina yields about 300 lb. of offal, worth about £20—$100—a ton. The farina itself is of very fine consistency, yellowish-white in colour, appetizing in appearance, of pleasing aroma, the distinctive fragrance of the potato being scarcely discernible, and, if preserved from the damp, may be kept indefinitely.

It is not imperative that the flake should be milled immediately. In the former condition the potato may be safely stored in bags in a dry place after the manner of grain. It is not even essential to turn it into farina at all. In the flake form it constitutes an excellent base for the other industries to which it may be applied. It may be distilled for the extraction of the alcohol, excellent whisky, as is doubtless well known, being made from the potato, while large quantities of British brandies are produced from the starch which, by treatment with weak sulphuric acid, is converted into glucose, which is then fermented. Thus, it will be seen, the flake really represents the starting-point for numerous applications, each of which has its individual commercial possibilities. The outstanding advantage accruing from the conversion of the potato into flake is that it enables the product to be kept indefinitely, without suffering the slightest deterioration, and without any waste being incurred. I have seen samples which have been stored for seven years, and which to-day are in every way as good as flake fresh from the machine.

In setting forth the composition of the succulent tuber I referred to the item waste, which in the analysis given stands at 1·4 per cent. This is the ultimate residue from certain operations, but is not common to all, as, for instance, in the production of farina, where everything of a solid nature is utilized. But in some branches of industrial use there results a residue for which, at present, no attractive purpose has been found, although there are hopes that even this insignificant fraction will ultimately prove capable of profitable exploitation.

Turning once more to the utilization of farina as a constituent of the loaf, we encounter a possible development which should play a very emphatic part towards rendering ourselves less dependent upon foreign sources of wheat supplies. A series of baking tests were conducted under ordinary commercial conditions. The farina was mixed with the wheat-flour in the proportion of 5 per cent. of the former to a sack of the latter. Government Regulation flour was employed. The sack contains 280 lb., so that the addition of the farina was equal to 14 lb. Seeing that the farina represents the potato in a highly concentrated form—5 to 1—the addition was really equal to 70 lb. of mashed potatoes—a degree to which no ordinary baker would be prepared to venture.

In the first test the bread was moulded by hand, and the sack produced 104 loaves, each weighing, ready for the oven, 2 lb. 3 oz., as compared with 94 loaves of equivalent weight normally obtained from the sack at this bakery. Under machine bread-making conditions, which obtained with the second test, and which was in accordance with the conventional practice of the firm in question, the yield from the blended flour, for technical reasons, was slightly lower, being 101 loaves, the weight of the loaf, ready for the oven, being the same as in the first experiment.

Baking was conducted at a temperature of 560 degrees, the loaves scaling barely 2 lb. 2 oz. upon withdrawal from the oven, and falling to 2 lb. net fifteen hours after baking. The bread was examined by experts who were present, and was declared to leave little or nothing to be desired. Judging from the public point of view it was held to be more attractive, owing to its increased volume, even texture, and perfect homogeneity, while it was found to be more digestible and satisfying.

In the hot condition the bread revealed only a slight trace of the peculiar fragrance of the potato, but this disappeared entirely upon cooling. The palate was unable to detect the potato-flour addition. The keeping qualities of this bread aroused particular comment. Four days after baking it was found to be still moist, while, upon the lapse of a fortnight, two loaves were rebaked and then found to be totally free from sourness. The striking success recorded was accepted by the expert opinion to be sufficiently conclusive: indeed, the suggestion was made that the proportion of farina might safely be increased to 7½ per cent. without allowing the presence of the potato to be detected. Tests were also carried out to determine the suitability of the potato-flour as an ingredient in the preparation of cakes and pastries. Here again the blended flour was unequivocally declared to yield better and more appetizing articles than was possible with pure wheaten flour.

But, taking the 5 per cent. addition as the figure coinciding with all-round requirements, it will be seen that the potato holds out great economic possibilities towards the reduction of the expense of the nation's bread bill. During the year 1916 our consumption of flour totalled 37,000,000 sacks, of which approximately 12,000,000 sacks represented imported flour. Assuming that 30,000,000 sacks were devoted to the production of bread, the aggregate yield of loaves was approximately 2,820,000,000. Had we used home-produced farina from home-grown potatoes to the extent of 5 per cent. we could have reduced the foregoing consumption of the wheaten product by 1,500,000 sacks, and that without losing a single loaf. As a matter of fact we would have been better off, because, on the higher average yield of 101 loaves per sack to which farina has been added, we should have obtained 2,875,500,000 loaves—an increase of 55,500,000 loaves.

The economy possible from the more enterprising utilization of the potato in connection with our daily bread is so impressive as to command attention, even to-day. Presuming that the foregoing figures still hold good, the blending of 5 per cent. of native farina would save 200,000 tons of shipping per year. To supply the requisite 188,000 tons of farina would involve 940,000 tons of potatoes. Seeing that the authorities, under the dictates of war, contemplated

setting aside 2,000,000 tons from the 1918 crop for the produ' tion of potato-flour, such a demand as indicated would not impose an intolerable strain upon our potato-growing resources. Were such a scheme carried to fruition we should also be able to recover 28,000 tons of valuable cattle meal to feed our stock during the winter season.

But, as already mentioned, the farina represents only one phase of a big issue possessed of vast possibilities. The other available openings for the products of the tuber would consume from four to eight times the volume of potatoes available. In Germany, out of the total 54,000,000 tons raised during the year only a round 4,000,000 tons have to be turned into flocken and schnitzel to save them from destruction by frost. In these circumstances there would appear to be scope for the cultivation of a further 5,000,000 tons, or twice the prevailing annual crop in these islands, with this advantage. The farmer, assured of his market and a fair price for his product, would be encouraged to extend his activities, and would be prompted to exploit considerable acreage of land which at present is regarded as waste, for the simple reason that it cannot be cultivated under existing conditions to profit.

Even disease and its ravages would be regarded by the growers with perfect equanimity were the industrial uses of the potato to be developed in this country. A farmer would not be faced with disaster in such an eventuality, as is the case to-day, because the diseased tubers would be available for the production of alcohol. Indeed, the more advanced the stage of disease the more suitable is the potato to this range of exploitation.

Lifting the commercial horizon, in so far as it affects the potato, demands support for other reasons. It would encourage inventive effort, which, in turn, would undoubtedly lead to the elimination of wastage in the household. Evaporative or dehydrating processes are already in operation, and it is only logical to assume that this tendency is capable of considerable expansion. The perfection of a simple and inexpensive process of drying the potato, either whole or in conveniently sized sections, as is common to culinary practice, capable of restoration, if necessary, to the original condition before cooking for the table, would benefit the whole community. "Spud drill," the *bête noire* of every

home, restaurant and hotel, with its concomitant wastage of time and heavy loss of valuable food material, would be eliminated. The removal of the greater part, or whole, of the 75 per cent. of the water contained in the raw tuber would decrease bulk, and effect a very valuable saving in transport. At the present moment the carriage of one ton of potatoes involves the useless dragging about of 15 cwt. of water which is superfluous. Only 5 cwt. of the load represents solid foodstuff. Dry the potato, expel the water, and from 4 to 5 tons of the product could be carried in the space now demanded to receive one ton. We have milk, peas, fruits, and other commodities innumerable in an evaporated form, which in their raw condition are associated with heavy proportions of water, so that there does not appear to be any valid reason why the potato should not be supplied to the housewife in a similar form and at a low figure. The perfection of such a process would completely obviate all waste because the offal—the peel and other inedible portions—would be recovered for conversion into food for animals, instead of suffering incineration. The recovery of the skin alone would bring within reach of the cattle-raiser for winter feed upwards of 30,000 tons of meal worth from £400,000 to £600,000—$2,000,000 to $3,000,000.

We, who live in these islands, scarcely understand the potato. We are content to cling tenaciously to the traditions established three hundred years ago. It is estimated that the British farmers lost over £6,000,000—$30,000,000—in handling their 1918 crop owing to the employment of obsolete and wasteful methods. The greater part, if not the whole, of this loss might have been averted had more enlightened methods prevailed concerning the utilization of the tuber. The above-mentioned figure does not take into account the losses suffered from disease and other causes, which must also have amounted to millions sterling.

Our system is as pre-historic as many of the agricultural methods practised by the fellaheen in the Land of the Pharaohs. The potatoes are dug and then collected for storage in big clamps. These have to be opened at intervals to allow the contents to be turned over and inspected, to ascertain whether or no latent disease has asserted itself. The potatoes have to be graded and bagged preparatory for market, while there is the formidable item of transport

to be considered. Between the harvesting of the crop and its ultimate disposal considerable handling ensues, while the difference in value between the "ware," or table, potatoes and the "chats," or those regarded as fit only for the pigs, is also very pronounced.

Contrast this method with what would obtain were we to develop the Continental system. After digging and grading the crop the farmer would merely be called upon to convey his harvest to the factory, when all anxiety, so far as he was concerned, would end. The method would be comparable with that pertaining to the handling of the wheat harvest in the great grain-growing countries, where the farmer is merely called upon to gather his grain and to haul it to the elevator. The saving in time and labour alone—two vital factors in these days—would be incalculable, while the risks of loss of crop would be completely obviated.

The super-scientific exploitation of the potato would extend far-reaching benefits in every direction. Not only would considerable stretches of derelict agricultural Britain be brought into productivity, but the very stimulation of the poor soils would bring about startling expansion in the production of artificial fertilizers, and would tend to stabilize such industries. In this way the recovery of waste in many other directions would be fostered—potash from the flues of the blast furnaces; basic slag from the dumps disfiguring the countryside in the vicinity of our ironworks; sulphate of ammonia from our gas and coking ovens; nitrates from the air. These would offer scope for employment, and tend to keep money within the confines of these islands, because the expansion of waste-recovery plants upon a sufficiently impressive scale in the interests of agriculture, with the local demand constituting the backbone of the trade, would encourage production for export. The labour thus absorbed would more than counterbalance the displacement experienced on the farms, and would redound to the benefit of the latter, because foods for poor and rich soils would be turned out in increasing streams and at lower prices. Thus it will be seen that any development of the potato, along modern scientific lines, and in such a way as to frustrate waste, must represent a big stride forward in the progressive cycle.

CHAPTER XII

CONVERTING NITROGENOUS REFUSE INTO SOAP

A STARTLING corollary of contemporary economic conditions is the spirited struggle which is now being waged between the table and the bath. The structural fabric of the human body demands a certain proportion of fat to ensure its smooth rhythmic working in precisely the same way as a machine requires oil. At the same time a cleanser is necessary wherewith to scour the external surface of the body to obtain protection against the ravages of disease. Fat is essential to fulfil this mission also. But there is an insufficient supply forthcoming to meet the complete claims of both. So the question arises—Which shall be satisfied? Little Mary or Mother Hygeia?

When Mégè Mouries, animated by the contention that it was preferable for the poor of Paris to be able to obtain a first-class nutritive butter substitute in preference to butter of doubtful quality, advanced his discovery of margarine as the solution to this problem, he little realized what a tremendous upheaval his invention was destined to achieve, or the staggering problem it would ultimately present to civilization. Certainly for many years his butter substitute, contrived from animal fat and milk, was regarded askance by the community in general. It was grudgingly conceded to be a possible food only for the poorest of the poor—those denied the opportunity from lack of means to purchase butter of any description.

For many years margarine was the object of unprincipled prejudice and obloquy. It struggled desperately for recognition. Inventive effort was expended freely to render the product more and more attractive in appearance and flavour, to attract all classes of the community. Indeed,

ingenuity was carried to such lengths as to produce a substitute impossible of detection from the genuine article, except by the most searching analysis.

But the rejected of 1871 has become the indispensable of 1919. The prevailing shortage of dairying products, confined not to one single country or even continent, but common to the whole world, has compelled the recognition of the virtues of margarine. The alternative is to go without, inasmuch as other edible fats, which might have taken the place of butter, have become unobtainable. But the British public, which fought the advance and claims of margarine for nearly half a century with a blind fury, and being forced to accept Hobson's choice, has encountered a pleasant surprise. The criticized butter substitute is found to be not so bad as it has been painted. With improving acquaintance opinion has veered round and now admits, somewhat tardily perhaps, that what was once considered to be only the poor man's butter is, in reality, an excellent foodstuff in itself, and preferable to many grades of the genuine article, some of which certainly are not above suspicion. To convey some idea of the enormous hold which this article of food has now secured upon the public it may be related that the turnover of one firm, specializing in the preparation of this product, aggregated no less than £22,000,000—$110,000,000—during the year 1918.

The increasing popularity of margarine speedily exercised a pronounced reaction upon the soap-manufacturing industry. The fats which were being utilized for the production of detergents were now demanded for conversion into foodstuffs. Hitherto, the soap-boiler has been regarded as the very lowest depths to which fatty waste can possibly sink. Thereto gravitated all the flotsam and jetsam of greases arising from other industries and in every stage of decay. But it did not matter how rancid the substance might be by the time it reached the soap-manufacturer. Here a scarcely credible metamorphosis could be effected, the most repellent raw material being transformed into the most attractive and fragrant acquisition to the toilet. Little wonder therefore that fats condemned as unfit or considered superfluous, though perfectly sound, for other use by man or beast, found their way to this mill. The soap-maker could absorb it all.

Thus, it will be seen, the soap trade is founded upon the commercial utilization of waste, and this raw material is drawn from the three kingdoms—animal, vegetable, and fish. As a matter of fact, the source of the fat is immaterial. It can be compelled to play its allotted part in the evolution of the cleansing agent.

The British nation is a big consumer of soap. Supplies of animal fat could never keep pace with the demand for this commodity. So the vegetable kingdom was compelled to pay fat tribute to the soap-maker, the coco-nut, palm-kernel, and other exotic nut products furnishing the requisite oil expressed from the fleshy parts of their distinctive fruits. Then the harvests of the sea were found able to contribute impressive supplies of oils. These were likewise impressed into service.

While the soap-maker was busily engaged in his task another chemical wizard arose. He had discovered a means of hardening or solidifying fish oils, which naturally are fluid except at very low temperatures. This was a sensational discovery. Hydrogen was the agent which achieved the apparently impossible, but it did far more than merely to harden the oil. By harnessing the gas to this duty the peculiarly pungent aroma, and distinctive taste of the fish, is completely removed from the oil.

This scientific achievement brought a further levy of waste into industry. The refuse from whales which had hitherto been permitted to rot, the inedible portions of fish from the canneries, even glut catches of oil-yielding fish for which no profitable market could be found, were treated to secure the oleaginous product, which was subsequently hardened and then turned over to the margarine industry. The hydrogenated fish oil has been found to furnish an excellent butter substitute, and one so closely allied to the genuine article in every essential respect as to demand the evolution of new and more exacting methods to determine its actual origin. It offers the closest approach to butter by synthetic agency which has ever been accomplished up to this time.

The striking improvements recorded in the process and manufacture of margarine arrested the attention of the soap-maker. He reflected. Here he was receiving fats of every description to turn them into a product which only

realized 4d.—8 cents—a pound. Yet he could take much of that self-same raw material, and by submitting it to another treatment he could produce an article which, as a foodstuff, was worth 1s.—25 cents—a pound. Why should he trouble to turn the fat into soap when he could derive three times the money by transforming it into an article of diet?

The war provided him with the opportunity for which he had been waiting patiently. The deficiency in butter supplies had to be remedied with margarine, which the public would have to accept willy-nilly. So the soap-maker switched over all the fresh sound fats from the soap-pans to the margarine mill. To-day thousands of tons of fats which five years ago would have been reduced to soap, this being considered as the only remaining utilization for the waste, is being turned into a food. The table has triumphed over the bath.

The devout worshippers at the feet of Hygeia may lament this inversion. But they need not despair. The world is not destined to go short of soap. Two British chemists, as a result of deep thinking, decided to attack the soap manufacturing issue *de novo*. They were not disposed to accept, at their face value, all that the text-books set forth concerning the chemistry of soap. They were rather impressed by the fact that the manufacture of soap had undergone no fundamental change since the first cake was placed upon the market, which was during the days when Pepys was walking among us taking notes. So far as soap chemistry theories prevailed the two chemists in question were Bolshevic in their attitude towards them, which was a fortunate circumstance.

A cake of soap is as familiar as a loaf of bread. Yet how little do we know about it, despite the brain-power which has been crowded upon its preparation. As a cleansing agent it is without a rival. Many big industries would have to close their mills to-morrow were their supplies of soap cut off. Yet its composition is very simple. It is composed of only two basic ingredients—fat, from which the glycerine has been extracted, and caustic soda. No matter how much you may pay for the article, be it a penny or half-a-crown a tablet, analyse it, and you will find that there is the soda which achieves the cleansing effect, and

the fat which gives the lather. It is quite possible a variety of other substances may be found associated with the two basic constituents, such as diatomaceous earth, Fuller's earth, farina, traces of disinfectant, colouring matter, cereal grains, perfume, and even water. But beyond rendering the soap attractive to the eye, pleasant to the nose, or to a certain degree germicidal, these additional materials perform no useful purpose. They are described as fillers, but in more candid language may be set down, for the most part, as sheer adulterants. Few articles lend themselves so readily to adulteration as soap. Was it not an analyst who, in the courts, described a piece of soap submitted to him for investigation as a striking example of water standing upright!

Although we profess to know so much about soap and its properties, we are really labouring in ignorance. No chemist can tell you explicitly whether the cleansing action exercised is the result of chemical, physical, or mechanical action. It is one of those questions which the seeker after truth had better not press home too energetically, because the man of brains would probably retort firmly, but gently, that the interrogation involves such a complex reply as to be beyond your powers of comprehension.

In our resolve to respect Hygeia we are most liberal in our use of soap. We are even woefully extravagant, although the blame cannot be laid upon the shoulders of the user. The water is the criminal. Did it but rigidly adhere to the chemical formula of its composition, namely H_2O, all would be well, but unfortunately it is associated with certain salts which it picks up from the soil during its natural movement. Water appears to exercise a bewitching fancy for two salts in particular—lime and magnesia. It is the presence of these salts which renders our water hard. I might mention that there are other impurities in the water contributing to wastage of soap, but the two mentioned are the worst offenders in this respect.

Lime and magnesia have a remarkable affinity for fat, and until their amorous inclination is satiated the soap cannot possibly settle down to the duty for which it is employed. The moment the soap enters the water a chemical reaction occurs, the lime or magnesia, perhaps both, attracting the particles of fat until it is impossible for another

molecule to be taken up. The extent of this attraction of the salts for the fat, and which the latter can no more resist than can iron filings battle against the drawing power of the magnet, may be gathered from the state of affairs prevailing in regard to the London water. The particles of lime contained in every 1,000 gallons of water attract approximately 15 pounds of fat contained in the soap before permitting the latter to lather. Seeing that fat enters into the composition of the average soap to the extent of approximately 60 per cent., it will be seen that about 25 per cent. of the fatty content of the soap is put out of action without performing any useful work.

The total loss of soap incurred during the year in London alone through this affinity runs into stupendous figures. The water consumption for washing purposes in the metropolis, according to Mr. Townsend, F.C.S., is 7,000,000 gallons a day. Consequently, at least 105,000 pounds of fat slip down the drains during the course of every twenty-four hours without fulfilling any useful service. The value of this loss, according to the same authority, may be set down at £1,000,000—$5,000,000—a year. This represents sheer waste, because the fats escape without extending a fraction of benefit to any one. It represents that section which has merely allied itself to the pernicious salts to form the lime-soap. From the foregoing one can form some estimate of the wastage of soap annually incurred throughout the country from the mere union of 25 per cent. of the fat with the lime—this figure fluctuates according to the degree of hardness of the water. Certainly it attains a figure which baffles credulity.

Confirmatory evidence of this waste is forthcoming from every hand-basin, bath, and washing appliance. It is revealed in the repulsive-looking greasy grey curds streaking the sides of the vessel, and which the user in ignorance generally dismisses as dirt removed by the soap. The housewife and launderer are often perplexed by the yellowish tone which certain garments assume, and the harsh and stickiness incidental to flannel after being washed. These defects are directly due to the lime-soap. Its presence is additionally exasperating owing to its extreme tenacity and penetrative powers, which wellnigh defy removal, except by the aid of powerful agents, the use of which is

to be deplored, because they precipitate further and peculiar worries and adversely affect the fabrics. In the textile industries, more particularly the woollen trade, the lime-soap is regarded as the greatest affliction upon the craft.

The question arises as to whether the lime cannot be removed from the water, or whether science can evolve a soap capable of hurling defiance at the lime. The solution to the first-named suggestion is distillation of the water before use, a tedious and costly operation, or the subjection of the water to a softening process to effect the removal of the lime before the soap be introduced. Great strides have been recorded in this last-named field, but, unhappily, the question of cost constitutes an adverse factor. Thus the true solution would seem to lie in the preparation of a soap capable of resisting the blandishments of the lime.

It was this particular solution which the two British chemists, to whom I have alluded, set out to discover, but many years of patient labour in the laboratory was necessary to register the first success. This was due to the fact that they set out upon quite an original and unexplored line of research. They recognized that the margarine industry must develop into one of the biggest industries of the country, and that, accordingly, the tendency would be to abandon the conversion of fats into soap owing to the heavier claims of the table, and the more remunerative return which would arise from such an industrial diversion. They were also aware of the fact that in preparing the fats for the table a certain proportion of residue must result. At that time there appeared to be no profitable field for the utilization of this waste. So they decided to conduct their investigations along the path which would admit of this refuse being employed.

The fatty constituent decided, they cast around for another staple which was indispensable to the process they had definitely resolved to perfect. For this they required protein, the governing principle being the perfection of a cereal soap, the nitrogenous compounds of which should be turned to cleansing duty. Proteins were available in infinite variety, but here again it was realized that it would be wanton waste to use an article likely to be in request to serve as food for man or beast. Then they discovered that there were ample quantities of protein running to

waste from commercial neglect. Accordingly, they decided to utilize these materials. The third constituent was the soda which must enter into the composition of any and every soap, but this did not occasion the slightest anxiety.

Equipped with these three materials they set to work. Experiment was tedious, and progress was slow, due to the fact that research was being conducted in quite a new and unknown field, absolutely deficient of any previous experience to serve as a guide. The first success recorded was the preparation of a soap in the form of a meal or powder coinciding with their ideas. This was submitted to the most rigorous tests, and the results obtained were quite in accordance with expectations. When this soap is introduced into the water no coagulation of the fat with the lime occurs. In this way the lime soap enemy was completely vanquished. As a supreme test sea-water was tried, with which it was found to lather as readily and as easily as when employed with distilled water.

The discovery represented a sensational achievement. It proved that something was awry with the existing theories pertaining to the chemistry of soap. Technical tests were undertaken, and they proved just as startling, because effects diametrically opposed to standard theories were observed. Whereas ordinary soap is insoluble in water, but soluble in alcohol, the cereal soap, so-called because of the starch which enters into its composition, is soluble in water, but absolutely insoluble in alcohol. The position is reversed.

A new era in soap manufacture was thus ushered in. The discovery came as a bomb-shell to the soap-making world, and, because it could not be explained through prevailing long-accepted chemical laws pertaining to this subject, it was ridiculed in certain quarters. To aggravate the situation chemists, who set out to fathom the secret of the new process by rigorous analysis, found themselves baffled. They could not determine the bases employed owing to the chemical reaction which had taken place during the preparation of the article, and from the circumstance that it belongs to colloidal chemistry. To indicate how completely the trade was baulked it may be mentioned that the chemist attached to one soap manufacturer in this country, and who had been requested to analyse a sample,

contemptuously dismissed the product not as a soap, but as a filler!

Undaunted by the flood of adverse criticism which they provoked, the inventors requested the industries to which soap is essential, and which were being harassed by the lime-soap bugbear, to subject the discovery to a commercial test. They did so, and were so surprised at the results obtained as to ask promptly for further supplies! It not only offered them the means to reduce their consumption of soap, but it performed the desired functions more efficaciously, and proved to be a complete panacea for the many ills which had heretofore afflicted the trade. So impressed were they by what the new detergent accomplished that they established its use in their works there and then, and to this day have never reverted to the article formerly used.

In the powder form the application of the cereal soap was somewhat restricted. Accordingly the inventors decided to produce it in the familiar tablet and bar form, to enable a wider appeal to be made, even to the home. As events proved it was far easier to attain the meal stage than to pass therefrom to the solid cake. In fact, at one time it seemed as if this desired end would never be consummated. It was only by dint of unflagging effort that success was ultimately secured, and the soap in tablet and bar form introduced to the market.

As the manufacture of soap from waste vegetable bases represents something entirely new, so do the actual methods of production. The revolution is complete. In preparing the conventional soap from 10 to 16 days are necessary. By the new process the cereal soap can be made in sixty minutes! Furthermore, the operation is clean, absolutely free from odour, and cold, no heat whatever being required, except to warm the factory during the winter for the comfort of the employees. The machinery necessary is also of the simplest and most inexpensive character. Under these conditions there is not only a very marked saving in time, but of fuel and labour. In these high-pressure days wastage of time is as criminal as the wastage of material, and one logically asks why spend ten days in consummating a specific end when one hour will suffice for the purpose?

The saving in capital expenditure is very impressive, being at least 75 per cent. below that demanded for equip-

ping the conventional factory. In other words, £10,000—$50,000—will provide an installation capable of turning out as much cereal soap as could be recorded with a plant costing £40,000—$200,000—devoted to the orthodox system.

The outstanding feature of the process is the complete absence of all boiling operations. The starch and protein-yielding material are passed through a mill to be reduced to a fine powder of the consistency of flour. This being a straightforward milling operation, the machinery ordinarily employed for grinding grain and other foods may be used. The flour is then emptied into a mixing machine, which is naught but the familiar dough-mixer used in the bakery. When the mixer is set in motion the caustic soda is admitted in a fine controlled stream. Directly the two materials come into contact the chemical reaction commences, the soda attacking the starch granules and breaking them down. Evidence of the battle in progress between the two chemicals is betrayed by the emission of the strong ammonia fumes, which prove that the nitrogenous compounds are being released. The admission of caustic soda is continued until the chemical reaction is concluded and the starch granules have been completely broken up. As the process is advanced the vegetable oil is admitted, the operation being so controlled as to yield a plastic mass of predetermined consistency. This is thoroughly kneaded after the manner of baker's dough. The subsequent processes are common to those of the ordinary soap manufactory, the material being passed successively through the milling, plodding, and stamping machines.

The raw materials for the provision of the essential protein are drawn from the extensive vegetable kingdom. But in no instance is any material having a claim upon the community or the animal world as a possible food used for the purpose. Dependence is placed rather upon the waste incurred by the preparation of other products, or of materials which have been condemned as useless for food purposes.

As a case in point it may be mentioned that a grain-carrying ship was torpedoed, sunk, and, together with the cargo, subsequently salvaged. The retrieved grain was dried in the anticipation that it might be found suitable for cattle-feeding. But the expectations were doomed

to disappointment. The wheat had been too completely impregnated with the salt from the sea. No other profitable use presenting itself, it was acquired for conversion into soap. It was ground in the usual manner and turned into the mixer. The presence of the salt, which had rendered the grain useless even as a cattle food, did not constitute an adverse factor. Had it not been for the cereal soap factory this cargo would have had to suffer destruction and have been completely lost to the community, whereas it was sold at a remunerative figure. Potato flour has likewise been utilized, but has not been widely exploited for the simple reason that this material constitutes an excellent foodstuff, either for man in the form of farina, or for cattle. Maize has also been used together with such products as rice, barley, oats, rye, and so on, but, except where the produce of this nature has suffered injury, it is not turned into soap. However, in those countries where a heavy surplus of such crops is encountered it would be found profitable to establish the cereal soap industry as a means of turning the glut to profitable advantage.

The principle governing the selection of the starch-yielding constituent is also observed in regard to the fat which is necessary. This is drawn exclusively from the margarine factories. It is a residue and at the moment possesses no other known marketable value. The ability to turn this refuse into an ingredient for soap has come as a distinct relief to the margarine industry, which threatened to be perplexed in the economical disposal of the accumulations. Seeing that the margarine manufacture is progressing by leaps and bounds, there is not likely to be any shortage in connection with the fat constituent of the cereal soap.

Supplies of a cheap and useless albeit rich starch waste product have also been secured in illimitable quantities. This has materially simplified the task of production. While a certain proportion of this particular raw material is secured for the preparation of an article of food, about 75 per cent. is discarded as waste. Since cattle will not eat it there remains no other field of utilization beyond the soap factory, for which it is eminently suited. In addition to the above-mentioned quantities ample supplies of this material are forthcoming, because it is freely used as ballast in ships sailing from the corner of the world in which the plant

grows in profusion. Should the demand for the food product which this substance yields increase it would not exercise any stringency, because the offal alone would be adequate to satisfy soap-making requirements. In pre-war days this waste cost only 10s.—$2.50—per ton, but during the war, owing to freight inflation, the price rose to £10—$50—per ton, while little was carried in ballast, more profitable cargo being readily obtainable. Consequently imports declined, only sufficient being brought into the country to furnish the needs of the industry from which the foodstuff is made. But the vegetable world is wide, and so it is by no means a difficult problem to satisfy requirements for this new industry, even in regard to starch-yielding wastes. The only other essential ingredient is soda. As enormous quantities of this article are manufactured in this country supplies thereof are readily assured and at an attractive figure.

There is one feature concerning this conversion of vegetable wastes into soap which deserves mention. Should all familiar starch-yielding products become unobtainable, a remote contingency, or attain an excessive figure, manufacture need not be suspended. As a last extremity sawdust can be utilized as the protein base. The possibility of turning sawdust into soap constitutes something distinctly new and novel to the industry, but the apparently impossible is readily feasible under the process described. Normally such an expedient would not find favour, inasmuch as certain difficulty is experienced in the complete subjugation, or elimination, of the fibre which is exceedingly resistant to the breaking-up action resulting from milling and the chemical reaction. Nevertheless, the circumstance that sawdust can be used in this connection opens up vast possibilities, and represents an opportunity for inventive effort in the perfection of simple and completely effective means to overcome the fibre difficulty.

So far as industry is concerned the use of nitrogenous and oil wastes in the form of soap has enabled startling economies to be effected. In the woollen industry alone the saving in the soap-bill ranges from 20 per cent. upwards, as compared with other soaps which have been used, while the silk and cotton crafts can point to like economies. The successful subjugation of the lime-soap fiend is beneficially

reflected in other directions. The effluents from the factories are conducted into the local drainage systems. The presence of the lime-soap in the drains provokes a host of troubles, such as clogging of the pipes and the fouling of traps and gullies, the curds proving exasperatingly tenacious and defying ready removal by ordinary flushing measures. Furthermore, the sludge reclaimed from the sewage, if contaminated by lime-soap, suffers material depreciation as a fertilizing agent because the grease, which is eventually released from the lime, tends to clog the soil.

But the most impressive fact to the ordinary user, both domestic and industrial, is the opportunity to reduce the wastage of soap. The fat content of the cereal soap is 50 per cent. less than that of the familiar article, and the whole of this is free to emulsify, from its refusal to coagulate with the lime in the water. Moreover, it contains two cleansing agents—the soda and the nitrogenous compounds—whereas the rival carries only one—the soda. Therefore it is not surprising to learn that in actual practice one pound of cereal soap will go as far, and do as much useful work, as two pounds of the ordinary soap. The ability to make a lather in sea-water is another distinct advantage which has been responsible for the widespread use of this commodity in the Royal Navy and mercantile marine.

Applied to London, the avoidance of soap-waste is certainly startling. It not only indicates how we can retrieve the £1,000,000—$5,000,000—at present escaping down the drains during the year, but the fat thus saved may be turned to more valuable account. The soap contributing to this gross loss is made from the very material possessing decided dietetic value. Therefore, by the law of economics, it should be diverted from its present use, admirable though it be to fulfil the claims of cleanliness, to the more vital application, especially in these days of stress and shortage. The table must take precedence over the bath.

CHAPTER XIII

TURNING OLD OIL INTO NEW

OIL is the blood of industry. Do we ever pause to reflect as to what would happen if we were suddenly to be deprived of our supplies of this commodity? Do we realize that without oil every machine would instantly be condemned to idleness, that our clocks would stop, and that it would be impossible for a train, steamship, tram, or omnibus to move a yard? The probability is that we have never given a thought to the subject, otherwise we should scarcely be so extravagant in our use of the article. Certainly we would not hesitate to expend appreciable effort in the recovery of as much of the waste as possible for further use.

Britain's normal importations of lubricating oil are in the neighbourhood of 68,000,000 gallons a year, and they cost us a round £2,500,000—$12,500,000. The tendency in regard to consumption is upwards owing to our enhanced industrial activity, so that we are becoming more and more dependent upon extraneous sources of supply for our requirements.

But the wastage is colossal. Rags and cotton waste, after becoming so soddened with oil as to be incapable of absorbing another drop, are discarded without compunction. There is scarcely a workshop, factory or office in the country which cannot point to improvidence in this direction. Such absence of thought is deplorable for more reasons than one. Not only is the oil, which might be recovered, irretrievably lost, but the very absorbent which from its textile nature might prove of distinct value for other applications shares a similar fate. Were only 50 per cent. of the oil wasted in this country during the course

of the year recovered, it would be possible to reduce our imports to a very pronounced degree. The reclaimed oil might not be of any value for its avowed purpose; but it must be remembered that lubrication does not constitute the one and only purpose to which oil can be applied.

The remarkable development of mechanical traction upon our highroads has been responsible to a marked degree for our increased consumption of this commodity, and this is the very field in which the greatest losses are incurred. There are thousands of garages scattered over the country. Many are of unpretentious calibre, but even the smallest of these establishments contributes its quota to the oil wastage issue. In cleaning operations oil is drawn off from engine crank-chambers and gear-boxes to run to waste. Rags are used for wiping and cleaning to be perfunctorily thrown away or burned when they have become too saturated for further use. The private motor-owner is probably as pronounced a contributory source of waste as the small garage, because he, too, is prodigal in his use of oil in every direction, and scarcely ever gives a thought to the retention of the waste for treatment to recover the oil and to release the rag for other duty, even if it be only for making paper.

At the moment the losses in this direction may not be so heavy as they have been in the past, for the simple reason that oil, in common with other commodities and in compliance with the inexorable law of supply and demand, has become more expensive. As the price rises the tendency to be sparing and careful becomes more marked, which only serves to prove that cheapness is the primary incentive to waste.

Wherever machinery has to be kept steadily and rhythmically moving oil is indispensable, so that it is not a difficult matter, when we recall the immense quantity of machinery which is kept running in these islands to maintain our industries, and to furnish our homes with such amenities as water, gas, and electricity, to recognize that our consumption of this article must necessarily run into huge figures. Our imports do not extend the true index to our dependence upon this article, because appreciable quantities thereof are derived from domestic sources of supply, such as coal and shales.

Machinery is insatiable in its hunger for oil. This

circumstance, combined with the increasing price of the article, has been responsible for the display of striking fruitful thought and experiment in the discovery of effective substitutes. This is particularly noticeable in our machine-shops. A lubricating agent must be utilized to facilitate the cutting of metals. Oil is admittedly the most efficient and best suited for the purpose, but many excellent compounds have been evolved to consummate the desired end and to conspicuous advantage. In one machine-shop the consumption of oil by the large automatic tools became so heavy as to prompt experiment. Many expedients were evolved and submitted to practical test, but they failed from some peculiar cause or other. However, perseverance brought its due reward. A substitute at last was found, with the result that oil for cutting was abandoned. By the change over the firm in question succeeded in effecting a saving of £30—$150—per month on each large automatic machine it had in use by the supercession of oil for cutting.

Doubtless opportunities for substitutes still exist in many other directions, but commercial rivalry under normal conditions, with enhanced prices prevailing in regard to costs of production, has not yet been sufficiently encountered to compel the use of the substitute in preference to the ostensible staple to secure manufacturing economies. But changes will, and must of necessity, be recorded as the struggle for trade develops.

In order to encourage the more economical use of oil in industry many interesting and to a certain degree efficient devices have been introduced. But for the most part these apparatus are devoted to the filtering of what may be described as dirty free oil. They scarcely venture beyond the removal of whatever impurities may be associated with the product in the suspensory form. They do not attempt to reclaim waste oil. Such timid treatment is readily explicable. Oil is a somewhat sensitive product. Its inherent qualities may be easily impaired. For example, oil prepared essentially for lubricating purposes must be possessed of specific qualities, of which viscosity is one and the most important. Then the requirements of lubricating oil fluctuate so widely. An oil designed for use with a high-speed engine, such as the petrol motor, is not adapted to the lubrication of a slow-moving steam engine. Yet

the depreciation of one single quality in any one grade is adequate to render the oil unsuited to the purpose for which it has been specially prepared.

The consumption of lubricating oil by the authorities during the war ran into imposing figures, and the liability to waste was proportionate to the consumption. Aeroplane engines and lorry motors, together with their auxiliary gearing, were in a constant condition of overhaul. Every time an engine or gearbox had to be dismantled many gallons of oil had to be drawn off. Consequently the handling of this enormous quantity of material to frustrate waste demanded special consideration, inasmuch as the oil could not be put back into the machinery after the latter had been reassembled. The authorities solved the problem by the perfection of an organization for the collection of this oil, which was returned to the oil-refinery to be re-conditioned, that is to be cleaned thoroughly and to have its original properties restored. By the observance of this practice of turning old oil into new the country was saved huge sums.

But there is a vast difference between official and civil conditions. So far as the former is concerned it was a comparatively simple matter to introduce an efficient organization to cope with the problem, while the waste oil was recovered in bulk, the hospitals for treating the engines of the aeroplanes and motor vehicles being centralized. It is the degree to which facilities for satisfying the civil demand are scattered which renders collection and handling of the waste along inexpensive lines so perplexing. It might be satisfactorily overcome if each garage and private owner undertook to maintain a waste-bin and to commit all oil-soddened rags thereto for periodical collection by a centralized authority, either municipal or private. The waste would be obtainable at a low figure, possibly free, inasmuch as the majority of garage owners would only be too glad to be rid of it. Possibly it would be found profitable to strike a bargain along the lines of free waste in return for the de-oiled rags, particularly if they were dusters or cloths. In this event the waste oil exploiter would only be called upon to incur the expense of collection and the treatment of the spoil. The return of the cloths would not entail further expense, because they could be returned

in exchange for another consignment of waste. The vehicle would have to make the journey in any event, and it might just as well make the outward trip laden as empty. It is quite possible, moreover, that the garage would be readily disposed to pay a slight charge for the cleaning of this material, particularly of cloths, so long as the sum was attractively below the price ruling for new supplies of the article. To the waste exploiter the value of the oil recovered should be adequate to defray all expenses of collection and treatment, and then leave a handsome profit capable of accretion from the disposal of the cleaned rags, which the garage did not require, for paper-making. It is merely a question of enterprise and organization, and in a large centre could be rendered a highly attractive and profitable venture.

This fact is borne out by the experience of private firms. Of course, it is essential that the volume of spoil handled should be of sufficient bulk to keep the plant installed for the reclamation of the oil going to its full capacity, or to one approaching the maximum. This is possible in the case of a large private company, such as a railway, electric-generating station, or even industrial plant.

One of the largest motor omnibus companies in the world was induced to consider the possibilities of this issue, and finally was induced to make the experiment. The "Iwel" plant in question was designed to turn out 6 tons of clean dry rags per week. This may seem to be an enormous quantity to accumulate during a period of seven days, but it must be pointed out that the company in question maintains 2,000 to 3,000 public vehicles upon the roads, as well as several garages and repair shops.

The first three months' experience served to bring home the economic advantages accruing from the scientific exploitation of this form of waste. During this brief period the company reclaimed 67 tons of rags for further use, the value of which at the time was set down at £1,007 7s. 1d. —over $5,000—while from this waste 4,080 gallons of oil, valued at £59 10s.—$297.50—were recovered. Here was a distinct gross saving of £1,066 17s. 1d.—$5,334—which figure was increased to £1,489 15s. 7d.—$7,449—on the credit side by the delivery of new rags to depots valued at £419 12s. 6d.—$2,098—and the sale of small rags unsuited

to further work for £3 6s.—$16.50. On the debit side the heaviest expenses were incurred in connection with the purchase of new rags, valued at £405 12s. 9d.—$2,028, cartage of the waste £152 17s. 10d.—$764.44, wages and salaries £157 15s. 1d.—$788.74, and coal £105 0s. 11d.—$525.22. The total outgoings amounted to £1,038 16s. 7d. —$5,194.14, which left a balance of £450 19s.—$2,254.72—actual saving recorded by the treatment of the waste. So far as the reclaimed oil was concerned, while this was unsuited to further utilization in its original province, it was found to form an excellent fuel for the operation of the Diesel engines, and consequently reduced the fuel bill on this account by a corresponding amount.

Another illuminating instance of the value of such waste is afforded by the working account for one year, furnished by one of the foremost British chemical manufacturers. The plant acquired in this instance comprised two turbine centrifugal separators, one washing machine, and one drying cabinet, the cost of which complete was £210—$1,050. In the course of the twelve months 350,000 wiping and other cloths were treated, and the losses incurred therewith were so slender as to demand renewals to the extent of only 15,000 new cloths, which, at 2s. 1½d.—52.5 cents—per dozen came out at £131 10s. 2½d.—about $657.55. The heaviest item in the operating account was wages—£132 12s. ($663). Other expenditure, including repairs, fuel, and interest on the first cost of plant, brought the total to £324 2s. 2½d.—$1,620.55. From the treatment of the 350,000 cloths 125 casks, or 5,000 gallons, of oil were recovered, which, at 10d.—20 cents—per gallon, represented £208 6s. 8d.—$1,041.64. The saving in cotton waste due to the soiled cloths being rendered available for further duty, set down at 392 lb. at £4 4s.—$21—per week, came out at £218 8s.—$1,092. Thus the total value of the waste recovered was £426 14s. 8d.—$2,133.64, leaving a saving, after deducting expenditure, of £102 12s. 5½d.—$533.11. The results of the year's working, therefore, enabled the firm to recoup approximately 50 per cent. of its original outlay, while the value of the oil recovered was only a little below the cost of the plant. The saving in cotton-waste —material which otherwise would have had to be provided—actually exceeded the capital outlay upon the plant.

The Lancashire and Yorkshire Railway Company, in consonance with the general practice, formerly utilized cotton-waste in its works for cleaning purposes. In these operations the material becomes saturated with ordinary lubricating, cylinder, and other oils, as well as grease from rubbing down the locomotives and parts. Some years ago it decided to abandon cotton-waste in lieu of sponge cloths, at the same time installing a plant for the recovery of the oil and grease from the soiled materials. During the year these sponge cloths are passed over and over again through the cleansing process, the operations being equivalent to the treatment of 6,500,000 cloths, and in this manner approximately 45,000 to 56,000 gallons of oil are reclaimed.

It does not matter to what phase of industry one turns, a certain amount of oil is possible of reclamation from the waste employed in connection with the conduct of the work. The volume recoverable naturally varies widely according to the nature of the trade pursued, and in some instances the individual yield may appear to be insignificant. But, during the course of the year, even in a small shop, the figure is certain to become impressive and well worth the efforts expended, as well as the money invested in the requisite plant, while, if the one instance be multiplied by the number of other similar establishments distributed throughout the country, the aggregate must necessarily be formidable. The table opposite furnishes a few actual results in the selection of industries specified.

It will be observed that the yield varies widely according to the industry concerned, but in every instance it will be observed that the figure is such as to render the process profitable, not only on account of the oil thus procured, but from the release of the waste or other absorbent for a further spell of useful service. If the waste, or other material, has been employed only for wiping parts, or mopping up free oil, passage through the oil separator will suffice, but if it has been utilized for general work and has become badly soiled, it requires washing. The sludge resulting from this process is subsequently passed through the oil-recovery plant instead of being thrown away, the reclamation thus being complete, while the rags or other textiles are passed through cabinets or other suitable facilities to be dried quickly.

Industry.	Material Treated.	Quantity.	Oil Recovered.	Per Cent.
			Pints.	
Agricultural machinery	Cotton-waste	18 lb.	9·75	54·16
Biscuit manufacture ..	Cotton-waste[1]	10 lb.	4	40
Colliery	Cotton-waste[2]	39·75 lb.	63	158·69
	Cotton-waste[3]	15·75 lb.	10	57·5
Cycle and parts ..	Rags	112 lb.	80	71·42
	Sponge cloths	1 gross	8	—
Foundry	Cotton-waste	13 lb.	11·25	86·53
Machine-tool manufacture	Cotton-waste	8·25 lb.	2·75	33·33
Motor-car	Cotton-waste	16 lb.	1·25	7·81
	Rags	12 lb.	2·75	22·91
Railway	Cotton-waste	14 lb.	2·625	13·75
	Cotton-waste[4]	10 lb.	13	130
Steel and iron-works ..	Cotton-waste	8·25 lb.	9·25	112·12
	Mutton cloths	2 lb.	1·5	75
Tramway	Cotton-waste	13 lb.	1·25	9·61
Wood screw manufacture	Cotton-waste	21 lb	13·75	65·47

[1] From engine-room.
[2] From blast-furnaces.
[3] From power-station.
[4] Axle-box waste.

But so far as industrial operations are concerned oil reclamation is by no means confined to the treatment of the waste and cloths. As already mentioned, oil is freely used in working metal, acting as the lubricant to the cutting tool. While trough facilities are provided to catch the oil to enable it to be used again, much clings to the turnings and other refuse. Even where works are not equipped with oil-recovery apparatus of some description or another an attempt to secure a proportion of what would otherwise be lost is made. The turnings are permitted to drain. The quantity of oil recovered in this manner, however, is very low. Certainly it does not exceed 40 per cent., because the oil clings somewhat readily and freely to the metallic surface.

Accordingly, in the best equipped factories, the practice is to submit the turnings to treatment. It is passed through the extractors and in this way at least all but 10 per cent. of the oil is recovered. When the solvent extraction process is exploited the recovery can be carried as far as 99 per cent., the fraction resisting recovery thus being extremely

small. The yield obtainable from such metallic residue from the machines is certainly sufficient to justify the treatment. In one shop, devoted to the manufacture of cycles and cycle parts, the oil recovery averaged 22 pints per 112 lb. of turnings treated. In another instance, where the production of agricultural machinery is conducted, 26 lb. of steel turnings and 23 lb. 9 oz. of brass turnings yielded 1·75 and 1·125 pints of oil respectively. One motor-car manufacturing firm recovers 1,200 gallons of cutting oil from the treatment of its weekly accumulation of turnings. This becomes available for re-use, and the absolute loss recorded is only about 10 per cent. In another instance, 2,440 gallons of oil were recovered from the treatment of 41 tons 17 cwt. of metal turnings, 900 lb. of rags, and 19,300 sponge cloths in the course of six months.

Another interesting experience in this field is worthy of record. It was found that the sawdust in the vicinity of certain machines, provided as an absorbent, became somewhat heavily charged with oil splashed and otherwise discharged from the machines. The presence of the oil-soaked refuse on the floor was construed as being a menace to the establishment, the hazard of fire being regarded as thereby increased. Accordingly, the floor was swept more frequently than otherwise would have been the case, the refuse being promptly shovelled into the furnace merely to secure its prompt and complete riddance. The sawdust was examined by a waste expert upon the occasion of a visit to the works, and he suggested, from the fact that oil oozed from a handful of the sawdust when squeezed, that the waste should be subjected to the "Iwel" oil-reclamation process, instead of being burned. The recommendation was followed, and the volume of oil thus recovered was found to be of surprising quantity. In fact, its value more than defrayed the cost of the small plant which was installed to treat it. So effectively was the sawdust found to be cleaned of the oil as to be redistributed time after time upon the floor around the machines. In this instance destruction of the oil-soaked refuse by fire represented a material loss in more senses than one.

While it is only within the past few years that the possibility of reclaiming oil from cotton-waste has aroused such earnest attention, it must be acknowledged that many firms

sought to reduce their expenditure by submitting their cloths and waste to a laundrying process. Of course, by this practice the textiles were recovered, but the oil was lost, while material expense was incurred in the conduct of the laundrying operations and the acquisition of suitable detergents. An interesting record of the cost of the respective processes is forthcoming from a certain firm in the South of England. It refers to two years' operations, the one referring to straight laundrying of the sponge cloths and waste, while the other refers to the latest method of dealing with such materials. Under the former *régime* the cost for the year was £219 9s. 2d.—$1,097.28. The heaviest items were for the purchase of sponge cloths and waste, the figures for which were £62 17s. and £137—$314.25 and $685—respectively. The cost of washing the dirty cloths at 7s. 3d.—$1.78—per week was £18 17s. —$94.25.

The firm then acquired a small oil reclamation and cloths-cleaning plant at a cost of £125—$625. During the year, under the new conditions, the expenditure on account of sponge cloths and waste was £25 16s. and £85 15s.—$129 and $428.75—respectively, but, for purposes of comparison, one-fifth was added to each item to counteract the slackness encountered, and to bring the subject more in line with the experience of the previous year. But even after making these allowances the total expenditure for these two articles came out at only £133 17s. 2d.—$669.28 —against £199 17s.—$999.25—when the textiles were laundered. Inclusive of all expenditure, including wages, washing materials, power, and interest at 5 per cent. upon the first cost of the plant, the total cost was £199 4s. 4d. —$996.8—as compared with £219 9s. 2d.—$1,097.28—for the previous year—a saving of £20 4s. 10d.—$101.20. But under the new system 716 gallons of oil, totally lost under the previous method, were reclaimed, which represented £11 15s.—$58.75, so that the total saving was £31 19s. 10d.—$159.98, representing approximately 25 per cent. on the capital outlay incurred for the installation of the plant.

In view of the economies possible from the practice of such a system as I have described, it is somewhat surprising that manufacturing firms should hesitate to include an

oil-reclamation plant in the equipment of their establishments. It is likewise somewhat difficult to bring home to them what really can be achieved by the scientific treatment of their waste. In order to popularize the practice, and to further the observance of economies which are inseparable from industrial operations under contemporary conditions, more than one British firm is prepared to advance an attractive commercial proposal. This is that the equipment should be installed and its cost defrayed out of the actual savings effected. Thus, in the case of the installation to which I have made reference, and which deals with the rags accumulating from the maintenance of public service vehicles, such a procedure was initiated. The capital expenditure involved in this instance was approximately £2,200—$11,000, but as the plant recorded a net saving of £450—$2,250—as a result of three months' work, which is equivalent to £1,800—$9,000—a year, it should be able to defray the whole of the initial outlay within about 16 months. However, all things being equal, it is computed that a reclamation plant submitted to the work which I have described should pay for itself within two years. Experience serves to support this contention, although, under the conditions which at present prevail, the possibility is that such a gratifying achievement would be fulfilled within a shorter period

CHAPTER XIV

BY-PRODUCTS FROM THE WASTE-BIN

THE exploitation of waste presents grand opportunities for pioneer research and investigation, not only to the chemist, but also to the layman who is fruitful of thought. In the praiseworthy determination to turn residues to advantage there is a tendency to follow the path of least resistance, and to apply them to the fields which most readily suggest themselves. This policy is regrettable. The true scientific solution to the problem lies not so much in the conversion of a refuse into a useful article, as the discovery of the precise province in which it is capable of giving the most lucrative and economic return.

This may appear to be a simple issue, but, as a matter of fact, it is one bristling with perplexities, invariably involving the expenditure of appreciable time and profound study. Some of the difficulties to be overcome are of an extremely abstruse technical order, and so can only be resolved through the indefatigability of the chemist, which goes to prove that the scientist really dominates industry and commerce. This fact was advanced many years ago, but it is only really acknowledged to-day.

A specific trade yields a conspicuous volume of residue of a distinctive character. From its composition and general characteristics it appears to be eminently adapted to a certain duty. But the chemist attached to the industry for which the waste is provisionally ear-marked delves into the problem, only to find that it is totally unfitted for what seemed to be an obvious application. He may even go so far as to assert his doubts as to the material possessing qualifications for any known use, owing to its unfavourable nature, or because application may prove to be too costly.

In such an event that residue must remain an apparently redundant product until a possible field for its utilization happens to be found.

A case in point may be cited. In the manufacture of boots for the Services enormous quantities of trimmings accumulated, owing to the specifications relative to the selection of skins for official needs being more rigid than obtains for footwear designed for civilian use. These trimmings proved to be quite useless to the trade, and so endeavour became concentrated upon the discovery of some other attractive utilitarian duty for them.

The main objection to this residue—curried leather—was the grease. It was decided to remove it—a relatively simple and commercially practicable operation. But in solving the one problem another, every whit as perplexing, was precipitated. The degreased leather could be used, but what was to be done with the extracted grease, the contribution of which was imposing? In appearance this grease resémbles the dubbin used for dressing footwear. Seeing that it was recovered from *new* leather the thought was entertained that this grease might be used in lieu of, or at least to supplement the supplies of, the conventional dubbin.

When the chemist took the proposal in hand he speedily shattered all hopes of turning the grease to such account. He produced an analysis which proved that the grease, instead of being a leather preserver as had been anticipated, was really a leather destroyer. The fatty acids were too predominant. Forthwith that grease had to be abandoned as a potential dubbin substitute.

Yet the chances are a thousand to one that the chemist will succeed in indicating a profitable use for this reclaimed fat from unused curried leather, because with war we have acquired wisdom. We are not so ready to throw away a substance just because we happen to be ignorant of an immediate industrial application therefor. Rather are we disposed to put forth a little exertion to strive to adapt, or to create, some useful range of service for it. There are hundreds of heads at work throughout the country attacking just such problems as the recovered grease from leather, and, consequently, from such a distribution and concentration of fertility of thought, it is only reasonable

to suppose that such issues will ultimately be fathomed satisfactorily to one and all.

Such close union of brain power and ingenuity is not confined to any one industry. The search for the most promising fields for waste-products is far too fascinating. Even the private member of the community is taking a hand in the great game, and is contributing, in varying degree, to the widespread success which has been, and still is being, recorded.

The rural housewife, in her lonely remote home, contributes to the amenities of country life by bottling her own fruits, following this practice to avoid wastage arising from a glut of produce in her own garden, or in her appreciation of the prolific luscious contributions offered by the wild hedgerow. She knows that the rubber rings with which the bottles are sealed can only be used once. Hitherto, she has always thrown the spent rings into the fire to get rid of them. Now, true housewife that she is, she reasons that surely these rings, while useless to her for fruit bottling, are suitable for some other equally important purpose. Forthwith she makes inquiries to ascertain the quarter in which they are likely to find favour, even if it be only to swell the scrap-rubber melting-pot.

The closely observant student of the countryside, during his autumnal rambles through the copses and spinneys, reflects upon the profusion of the hazel-nut, and the circumstance that this crop is permitted to fall to the ground to rot, or to suffer only partial appropriation by the thrifty squirrel. Surely, he ruminates, such wild fruit possesses some commercial value. The shell can be turned into a high grade charcoal for the laboratory, while the nut itself is rich in oil, which it ought to pay to extract, leaving a residue to offer an excellent winter-feed for cattle. As he ponders upon the problem the fact dawns upon him that the country is rather more disposed to import vast quantities of a similar product, derived from the coco-nut, palm kernels and other exotic fruits, than to exert itself a trifle to turn its domestic resources to account.

It is useless for him to try to rouse the country to realize the wealth it is allowing to slip through its fingers. Any suggestion concerning the recovery of the hazel-nut meets with the instant retort that there is no organization available

to conduct the requisite collection of the nuts in due season, and that the end would not justify the means, owing to the time, labour, and expense involved. But when we come face to face with stress such potential wealth of wild rural Britain meets with recognition. Was it not stringency which prompted the harvest of the blackberry crop in 1918 to avert the threatened shortage of jam? Yet the very success which attended the gathering of the blackberry crop, and the zest with which the task was pursued by the juvenile section of the population of the country, should suffice to indicate that the hazel-nut might just as profitably, easily, cheaply, and efficiently be gathered to swell the output of margarine or to be turned to other industrial account. Surely, by the exercise of enterprise and thrift in this direction, we might be able to reduce our expenditure of upwards of £16,000,000—$80,000,000—a year upon oils and materials for the preparation of edible foodstuffs for both man and beast to a certain degree, and thereby foster additional native industries. If further testimony be required to demonstrate the facility with which such a wild home-product might be secured were collection attacked along the proper lines, does not the acquisition of the horse-chestnut crop of the country in 1917 suffice?

The photographer is another lamentable, albeit unconscious, contributor to the great wastage problem. There are hundreds of thousands of enthusiastic amateurs scattered up and down the country. Their consumption of glass negatives and films during the course of the year runs into colossal figures. Yet of the millions of exposures which are made how many can be construed into successes, or, if satisfactory, need be retained for any prolonged period? If preserved the negatives accumulate at an alarming rate, to present exasperating posers in regard to their safe storage.

What becomes of these ruined and superfluous negatives? So far as the films are concerned there is no mystery. They meet an unmourned fate in flames. But the glass negatives are somewhat more troublesome to scrap. Some idea of the immensity of the hoards of negatives possessed by both amateur and professional photographers was revealed during the war. The stupendous production of anti-gas masks was responsible for huge inroads upon our glass manufacturing

facilities. When the United States of America entered the arena, and concluded arrangements in this country for the supply of this indispensable article of equipment to the American troops, the demand for suitable glass was forced up to such a level as to tax our producing capacity to a supreme degree.

The glass was required to furnish the eye-pieces to the masks. These were circular in shape, and about 2¼ inches in diameter. Each eye-piece was made from two discs of glass which were superimposed, with a thin layer of xylonite between. The last-named was introduced to extend enhanced safety to the fighting men. A ricocheting shell splinter might strike the goggle, shattering the outer layer, but the inner section might possibly escape all injury. Even if the blow were sufficiently severe to smash both sections of a single eye-piece the goggle was not certain to be shivered like the window-pane struck by a stone. The intermediate layer of xylonite nullified the force of the impact to a striking degree, any starring that might be communicated to the inner disc not necessarily being in line with that produced on the outer glass, except, of course, in instances of a direct hit. Moreover, the glass was deprived of its characteristic tendency to splinter under a blow, owing to the intervening thin film of xylonite. Photographers will appreciate the situation from their experience with their glass negatives. When dropped the glass may be smashed into a hundred fragments, but they are invariably held in position by the attached film.

The glass required for this purpose had to be of a certain standard, not exceeding one-sixteenth of an inch in thickness, and free from flaws. The authorities discovered that photographic negatives were made of the very material desired, and realized that here was a peculiar opportunity to remedy the deficiency they were experiencing in regard to the supply of new material from the accepted manufacturing sources. Accordingly, appeal was made to all photographers to turn out their stocks of dismal failures and negatives which need be retained no longer, and to surrender them to the Government.

The demand was certainly pretentious. The eye-pieces were required at the rate of 500,000 a week. As two quarter-plate negatives were required to produce a single goggle—

four for each mask—it will be seen that 2,000,000 discarded quarter-plate negatives were sought weekly to keep pace with demand. Of course, larger-sized plates enabled the discs to be cut more economically, but it is the quarter-plate which has the biggest vogue among the huge army of amateur photographic enthusiasts, owing to questions of expense, and so appeal was especially made for plates of this size, in the feeling that here was the richest mine to be tapped.

The negatives were stripped, the emulsion being dissolved from the foundation by the aid of chemicals. In this manner the nitrate of silver content was recovered to be turned to profitable account. The metallic yield from the individual plate is negligible, but, under quantitative treatment, as in this instance, the reclamation was rendered profitable. No attempt was made to exploit the emulsion, but there seems to be no reason why this should not have been utilized.

All trimmings from the glass in cutting the discs were carefully garnered. These formed what is known as "glass cullet," which was returned to the glass-makers. Being of high quality the cullet commanded a ready sale, the glass obtained from re-melting being used for the fabrication of ink-bottles, salt-cellars, scent-bottles and a hundred and one other articles in urgent request, while an appreciable quantity was again converted into the base for further photographic negatives.

Plates exceeding the officially inscribed thickness of one-sixteenth of an inch were not unceremoniously consigned to the melting-pot, but after being stripped of the emulsion, were sold to the trade for contrivance into the *passe-partout* photographic mounts so much the vogue to-day among enthusiastic amateur photographers, for picture framing, and numerous other applications for which their dimensions and the quality of the glass rendered them eminently suitable.

Turning to another phase of industry, gloves of every description have soared in price, irrespective of the materials used in their production. Even those contrived from stout textile, which five years ago were readily procurable for a few pence, commanded shillings a pair. In this instance the rise in price was primarily due to the call for vast quan-

tities by the munition factories to extend a measure of protection to the hands of the workers, more especially the women. Toiling Britain became converted to the gauntlet habit, so pronounced across the Atlantic, as a result of war.

As may be imagined, from the character of the work involved, these gloves suffered speedy deterioration, becoming saturated with grease and grime from the handling of metal and the operation of machinery and tools. One firm found itself saddled with 112 lb. of these dirty gloves every week, and the item "glove renewals" consequently grew somewhat impressive. Feeling that this expenditure might be capable of reduction, the firm sought a simple and inexpensive cleaning process for the removal of the grease, to give the gloves a new lease of useful life, the fact having been ascertained that the textile itself suffered little injury as the result of a few days' wear and tear.

Experiments were made and the requirements of the firm were met very effectively. Not only were the gloves turned out clean and sound, enabling them to be used over and over again until the textile was worn out, but the oil and grease with which they were sodden was recovered. This was cleaned and found serviceable either as "cutting oil" for use with the tools, or as fuel oil for engines of the Diesel type.

I have previously referred to the reclamation of the grease from the leather trimmings accruing from the manufacture of boots for the Services. The trimmings represent pieces of good sound leather, of all shapes and sizes, some of the fragments being of relatively large dimensions. A selection of this waste from two large Northampton factories was secured. It was carefully sorted. The larger pieces were found to be useful for providing patches of varying sizes, capable of profitable use by the trade for the repair of civilian footwear. The larger sections of soleing leather were similarly sorted, having been found adaptable to what is known as "packing-up" in resoleing operations.

By the time this sorting had been completed only shreds and tatters of leather were left. These were degreased for the recovery of the dubbin-like fat already described, and to leave the leather quite clean, soft, and pliable. The fragments from the uppers were again examined, and found capable of further selection to serve as raw material for

another industry which was being sorely harassed from the non-availability of the raw leather upon which it was normally dependent. This was the fabrication of the tiny, circular, serrated-edge leather discs or " tufts " used in the making of mattresses for bedding.

This discovery proved to be extremely opportune. Leather had grown so scarce that the normal supplies for this range of duty had been summarily cut off. Yet mattresses cannot be made without these tufts, and the bedding trade had been striving diligently to discover the suitability of certain suggested substitutes, when along came the suggestion that degreased uppers waste from the boot factories might possibly satisfy all demands in this direction.

The ability to exploit the residue in this manner provided the Lord Roberts' Memorial Workshops with an additional field for activity, of which due advantage was taken. Then it was found that the soleing leather might be put to equally useful service. Many trades were reduced to a quandary from the inability to obtain leather supplies from which to make washers. This waste was found to fill the bill very neatly, because as with boots so with washers—there is nothing like leather. Certainly no substitute therefore has yet been found able to fulfil the required duty so efficiently as the hide from the cow, although there has been no lack of enterprise in this direction. The wisps and scraps of uppers and soles of leather remaining from this selection—mere shavings and shreds—are ground up and converted into fertilizer.

That leather trimmings from the boot factories, hitherto regarded as absolutely useless, are forthcoming in sufficient quantities to fulfil the claims of the tuft and washer trades have been definitely ascertained. The residue is far more imposing than might popularly be conceived, especially in connection with the production of Service boots. Organized collection alone is required to bring this source of possible supply into contact with the market. From three factories alone approximately 2,300 lb. of trimmings are obtainable every week. Multiply this yield by the number of boot factories in the country, and it will be seen that this leather waste could supply adequate material to allow tufts and washers to be turned out in their millions during the course of the year.

Even the manufacture of civilian footwear, especially of feminine fancy boots, yields its quota of waste. But the contribution is not so pronounced as with Service footwear because wider scope exists for working up the surplus. Nevertheless, all waste, no matter what its character may be, has a utilitarian value. The cloth remnants find a ready market for the manufacture of paper. The cork sole cuttings, composed of cork, with cotton and wool attached, are similarly retrieved by the ton. Sorting enables the cork to be recovered for the manufacture of linoleum, the cotton for the paper mills, and the woolly component for shoddy.

Finally we get the floor sweepings—a collection of leather, textiles, and other materials recovered by the aid of the broom. So far as Northampton is concerned—the system probably prevails in other boot-making centres—the practice has been for the municipal authorities to collect these accumulations and to remove them to the dust-destructor for incineration. This was regarded as the simplest, cheapest, and most efficient method for their disposal.

Salvage experts examined these sweepings. They found a far more utilitarian use for this waste. It was worth £2—$10—a ton for conversion into fertilizer. Seeing that about 1,000 tons a year of these sweepings are recoverable from two or three factories it will be seen that we have been content to send £2,000—$10,000—annually up the chimney of a dust-destructor from sheer lack of foresight and the expenditure of a little thought and trouble during the very period when our land is clamouring for nitrogenous fertilizers.

Before leaving the boot trade I might refer to another recent development concerning a certain waste which is of decided interest. Patent cuttings presented quite a different proposal from the odds and ends of ordinary leather. The glossy finish was held to be a drawback, because obviously it would have to be removed before the material could be submitted to any of the purposes described. It was anticipated that such preliminary treatment might prove too expensive to render the recovery worth while. But a simple and cheap process for securing the patent in the form of a fine dust—"curriers' powder"—was found. This left the leather free for further exploitation. Then the question of turning the reclaimed dust to account arose. Inquiries

were made, but there appeared to be no opening for it. It looked as if this curriers' powder would have to be set on the shelf in company with the recovered grease against a day of brilliant discovery upon the part of the indefatigable chemist.

But a firm specializing in a peculiar phase of activity came along. It was experiencing distinct difficulty in finishing off the work with which it is identified with the requisite degree of satisfaction. Suddenly it had occurred to the technical staff that this fine dust might possibly extricate them from the dilemma with which the firm was confronted. The dust was submitted to trial. The tests are not yet conclusive, but the results so far recorded have fully justified the utilization of this material; certainly the firm in question is disposed to concede its employment as the solution to their difficulty. Should these expectations be fully realized there is every indication that the demand for curriers' powder will become exceedingly heavy, and from a quarter which will arouse widespread surprise. The consumption in this realm will eclipse that ever likely to be recorded in connection with footwear. While industrial ethics preclude the mention of the precise application in question, it may be added that it is about as closely allied or has as much in common with boots as the use of cheese in the production of steel.

The one overwhelming obstacle to the commercial utilization of waste is organized and cheap segregation and collection. This difficulty is aggravated when the refuse in question happens to be in a combined form, that is to say, when two or three—perhaps more—widely divergent substances are associated to produce the one article. Possibly only one of the constituents possesses a known market, or it may so happen that each of the component substances has a distinct market but only in its individual form.

As a rule any waste of this character from industry is regarded with contempt by the approved specialists in waste collection—the itinerant merchant or the marine store dealer. Both these traders prefer to conduct their operations with approved straight and unadulterated materials. If the waste happens to be of the combined character, they realize that they must expend a certain amount of time and labour in its separation before carrying out its sale to advantage.

As they are not inclined towards such exertion they refuse to accept the residue.

It is a foolish policy and one which directly reacts against their own interests. Such combined waste can generally be procured at a trifling figure. The factory in which it accrues cannot afford the labour or time necessary to bring about the separation of the constituents. Yet when separation is completed each class of material at once attains its true value. Resolution of combined waste into its components does not involve any skill, while it is immaterial how roughly the task is performed. The merchants to whom allusion has been made will also spurn waste of undoubted market value if it has been dressed or impregnated with another substance. They will jump at rags no matter how soiled and loathsome their appearance. They know the dirt can be removed readily and cheaply, but they never pause to reflect that substances used for impregnating textiles may be eliminated just as easily. Moreover, unlike dirt, the recovered dressing may possess a distinct commercial value in itself.

Waxed flannel is a recognized commodity, and, in fabricating articles therefrom, appreciable quantities of trimmings are obtained. One firm was in a quandary as to the disposal of this waste. No rag-and-bone merchant would touch it. The firm was quite prepared to sell the refuse at a low figure, fully confident that it could be turned to some profitable purpose. The material was investigated, and the separation of the wax from the woollen base was found to offer no supreme or expensive difficulty. Yet the extraction of the wax made all the difference in the intrinsic worth of the waste. At that time the de-waxed flannel fetched 85s.—$21.25—a hundredweight, while the wax, which was a high-grade product, was also of distinct value because it was available for re-use.

A similar problem cropped up in connection with oilskin trimmings resulting from the manufacture of garments and other articles. The factory concerned stated that the waste was somewhat pronounced from the magnitude of its business, but what to do with it was beyond their knowledge. Experiment proved the separation of the oil to be an easy matter, and so the release of the cotton textile was secured. In the degreased form the trimmings fetched

from 50s. to 60s.—$12.50 to $15—a hundredweight at the time, while the oil was also a valuable by-product and was readily absorbed by industry at a favourable figure.

It is a moot point whether any other textile enters so extensively into industry in some form or other as cotton. Consequently cotton refuse is recoverable in immense quantities from the factories and workshops where this textile is converted from the piece into garments and other utilitarian articles. These trimmings for the most part are unsoiled, but equally imposing are the contributions from the domestic rag-bag and the refuse bins of other trades, whence the residue is forthcoming in a more or less soiled condition. But a simple cleaning process renders it suitable for further use. Should all possible or promising applications be exhausted to no effect then this residue can always be absorbed by the paper-mill. The paper-making industry may truthfully be described as the salvor's sheet-anchor; certainly there is no excuse for consigning any cotton fabric to the flames while the paper-maker's craft flourishes.

But in the majority of instances this waste, as already mentioned, is associated with some other substance, for the simple reason that it constitutes an ideal inexpensive base, or foundation, for carrying the medium desired. Take the rubber mackintosh sheeting as a case in point. Here the cotton sheet foundation is impregnated with rubber to secure the desired waterproofness of the material. But the trimmings need only to be submitted to a solvent treatment to bring about the removal of the rubber, when the cotton base at once becomes released for the paper-maker. The rubber is also retrieved to advantage because it is quite pure. Emery cloth, which has been discarded as too worn for further use, may be similarly treated, the recovery in this instance being of triple value when conducted upon a large scale, comprising respectively the emery powder, the oil, the fabric base, and possibly the metallic dust.

The extraction of nicotine from tobacco is a flourishing industry. This trade has been built upon the commercial utilization of waste, the raw material comprising tobacco declared as unsuitable for the generally recognized commercial applications. The nicotine is extracted for the preparation of insecticides and other commodities for which the juice is eminently adapted.

To obtain the nicotine the discarded tobacco is placed in linen bags. Subsequent treatment follows certain lines. As may be imagined, owing to the extremely oleaginous or gummy character of the juice and grease, these bags become clogged during the extracting process. In course of time they become so saturated as to be unfit for further use, not through any failure of the actual fabric, but because the fine mesh of the material has become choked. Owing to their admitted repulsive character the bags were thrown away or burned.

One firm specializing in this industry accumulated soiled bags to the extent of approximately 2,000 per month. It had never contemplated the feasibility of subjecting them to any treatment, probably because new bags were relatively cheap. But, as a result of the national demand for linen for more vital purposes, and the exceeding scarcity of the basic raw material, which had the effect of sending the price of flax from £54 to £280—$270 to $1,400—per ton, the idea of recovering the bags assumed more pressing significance. A sample was taken and submitted to a degreasing process. It was discovered that the combined action of steam and centrifugal action speedily separated the clogging gummy constituents from the fibres of the linen. When examined after treatment the bags were found to be quite free from every trace of the nicotine, and it would have been difficult for the uninitiated ever to have identified them with the industry of nicotine extraction. The tobacco juice was recovered in appreciable bulk, but what was far more important was the reclamation of the bags. In the cleansed condition they were worth from £20 to £40—$100 to $200—per ton.

To enumerate all the industries from which odds and ends of cotton-waste are derivable would demand too much space. There are stalks and ends of plumes from the fabrication of artificial feathers, tangled bundles of loose tatters, fragments of silk in a thousand and one forms, mercerized and natural, and so on. The yield from a single factory or workroom may be trifling, perhaps, while there is the rag-merchant to hand to take delivery of this residue. A firm may readily concede the preservation of its waste until it assumes a formidable bulk to be more troublesome than it is worth, as well as littering the factory or occupying space

which can be put to more valuable account. So it generally throws the residue into the furnace, but the utilization of such waste as fuel represents the most costly method of disposal which could be practised.

The losses arising from such action are immense and deplorable, more especially when it is remembered how easily and readily they might be avoided. It is somewhat consoling to reflect that, to-day, despite the many perplexities involved, the salvage of this refuse is being attacked along serious lines. Factories and workshops are beginning to appreciate that these residues can always command good money from the pulp-makers, the result being that much less residue is being lost through the too handy furnace than formerly. Parings from ladies' velour hats, felt trimmings, odd pieces from billiard-table cloths—woollen fragments in a thousand different forms are now finding profitable utilization. All such waste is being snapped up greedily by the shoddy mills. During the war some of this waste was somewhat freely absorbed for carrying out elaborate camouflage schemes to screen the movements and disposition of troops, guns, and transport from the prying eyes of the enemy, but to-day it is all being released for the reproduction of clothing material, blankets, and other articles innumerable—all of far-reaching import to the community.

My Lady, when she contemptuously discards her straw hat, does so without venturing a thought as to its possible further value, except, perhaps, as a lighter for the kitchen fire. But the abandoned headgear, together with the straw refuse plaiting from the factory, now possesses a market apart from that for making paper. It is being used extensively for stuffing the backs and seats of cheap furniture. During the period of war this waste was found suitable for another mission and one which still obtains. This was as a substitute for wood-wool, which virtually disappeared from the market. Wood-wool is prepared from wet wood, and, naturally, a certain period of time must elapse to allow it to dry before it can be set to its designed service. When wood was cheap and plentiful this delay presented no handicap, manufacture being continuous, but during hostilities wood became counted among the luxuries of commercial life. It was far too valuable to be shredded into

wool, except in severely limited quantities, to act as packing.

As a result of the experiment induced by stringency, plait from old hats, and the factory waste, were found to be quite as good as the wood-wool in this capacity. The colour of the straw, faded or otherwise, constitutes no disadvantage. Consequently, to condemn the abandoned summer friend of the head to serve as a fire-lighter represents approximately its least economical application, although it may come as an equal surprise to learn that the perfect dream of the milliner's creative faculty may reappear as the protective covering to chocolate and confectionery during transit from manufactory to the retailer in its familiar wooden box.

Discarded umbrella coverings may not appear to possess any further attraction except to the paper-maker. But the waste-expert declares otherwise. A flaw in the silk covering or possible damage wrought while attaching it to the frame no longer constitutes a passport for the material to the dust-bin or flames. Finger-stalls and eye-shades may be contrived from this waste. For making eye-shades it is only necessary to cut a piece of cardboard, likewise retrieved from the waste-bin, to the desired size and shape. Then, by the aid of a little glue the silk section cut from the abandoned umbrella covering may be fastened to the cardboard base.

During the course of the year thousands of tons of string are made in these islands. What becomes of it all? One industry utilizing this material found itself saddled with about ten tons of odd lengths, which, thrown into the waste-bin, became a tangled mass. The bewildering array was examined by an expert. He found that whereas some of the pieces were of only a few inches, others ran to three, four and even more feet in length. He contemplated the pile and concluded that it would never pay to unravel the tangle. It was a task calling for weeks of labour and infinite patience.

His first inclination was to hand over the bulky pile to the paper-mills to be pulped. But further consideration of the quantity of the long lengths of string in that junk heap prompted an alternative. String, neatly prepared in large balls, is furnished to prisons to serve as raw material to the

prisoners engaged in the overhaul and repair of bags. Why not send this collection of waste to the penitentiaries? There the time occupied in unravelling the tangled jumble is of minor importance. Prison labour does not count, while the task is no less fruitful than that of picking oakum. Forthwith the string was forwarded to these establishments, and was found to meet the purpose very satisfactorily. Not only did this waste release an appreciable quantity of new string for more valuable applications, but it also enabled an appreciable saving in cost of bag repairs to be recorded, while the work was just as neatly and efficiently fulfilled with the odd lengths as with new string.

In another case a farmer of a thrifty turn of mind saved all the odd lengths of binder twine accruing from the use of the self-binder to harvest his crops. When untying the sheaves for threshing he threw the lengths into a bin, and in this way amassed quite a respectable pile. It was promptly acquired by paper-makers who paid him 25s.—$6.25—a hundredweight. This satisfactory result should prompt all our farmers to exercise like economy in this connection. They would find it to their financial advantage to do so. The annual consumption of binder twine in these islands runs into big figures. In 1917 we imported 115,086 hundredweights for which we paid £417,168—$2,085,840—while in the previous year the figure was 212,639 hundredweights valued at £550,104—$2,750,520.

To assist in the harvesting of the 1918 grain crop the Food Production Department purchased 20,000 tons of this apparently insignificant material to ensure farmers receiving adequate supplies. When the grain is taken in hand to be threshed the recovery of this waste should be an easy and simple matter. It is only necessary to provide a few sacks to receive it. Even at 12s. 6d.—$3.12—a hundredweight it would prove a profitable by-product to the farmer, and enable him to recoup a certain proportion of its outlay upon this item, while it would tangibly assist another industry. The recovery of 75 per cent. of the above-mentioned 20,000 tons, provided through the instrumentality of the Food Production Department, would have represented approximately £140,000—$700,000—and have contributed towards the production of 2,500 to 4,000 tons of paper.

To indicate how organized collection influences the value

of so-called waste and its economical use, the experience of an importing house in the City of London deserves narration. This firm accumulated an appreciable quantity of the special packing paper with which the wooden cases are lined. This paper is very tough and is strengthened with thick cotton netting of open mesh, while it is also waterproofed. The firm did not know what to do with the waste, but was reluctant to turn it over to the paper-maker. Inquiries were conducted, to result in the discovery that a similar paper was used for packing motor tyres. Thereupon a motor tyre dispatch firm was approached with the suggestion that it might find it profitable to acquire this residue. The tyre-packers were buying the paper specially manufactured for wrapping purposes, but test revealed that this packing case lining was equally adapted to the duty. Thereupon it expressed its readiness to take over all the residue from the importing house at 25s.—$6.25—a hundredweight. Unfortunately, in this instance, the offer could only be met immediately with some 56 lb., but if all the firms importing from the United States and other countries were to conserve the paper lining to the cases coming into their hands, and to dispose of it to other trades for which its peculiar construction renders it specially suitable, there would be a material reduction in the strain imposed upon our domestic paper-mills, while a proportionate quantity of this indispensable commodity would be released for other applications.

We are all familiar with the little disc of metal having a bent-over corrugated rim and a cork lining which has displaced the glass stopper and driven-in cork for sealing bottles. It is commercially known as the "Crown Cork." A slight angular prise and the cap flies off. It is one of those little inventions which have proved a great boon to many trades, especially to those identified with the bottling of beers, mineral and drinking waters. Incidentally it has proved a great money-maker.

An observant mind discovered that the tiny cap suffers little or no damage from its summary removal. Why should it not be used again? So he reasoned, and conducted experiments to establish the feasibility of such a suggestion. He has succeeded completely in his task. By a simple, inexpensive process, which he has devised, these crown corks can again be rendered as serviceable for their designed

purpose as new corks. As a result of his brilliant ingenuity, and saving turn of mind, this observant and practical waste exploiter is readily disposing of the renovated article at eightpence per gross—16 cents—which is 300 per cent. below the price of the new article.

That inventiveness in its application to economy is fascinating and profitable is demonstrated very convincingly by the array of contribution of sound practicable ideas which are being contributed towards the "save the waste" problem. The potato-peelings attracted one economist, who with this apparently useless material and no other contrived an attractive biscuit. Another experimentor, securing a few ounces of fat from a whale, which had been cast upon the beach to the peril of the residents in the vicinity, converted them into a solid white block somewhat reminiscent of candied sugar, by submitting the fat to the hardening process. Another effort represents a bold attempt to turn the spent tea-leaves to economical account. In this instance this waste was mixed with another residue—sawdust—and some inexpensive, readily combustible agent, such as naphthalene, also waste. The mass was then pressed, and offered a presentable and effective cheap fire-lighter.

Within the space of this volume it is impossible to exhaust the many efforts which are being made to turn apparent waste into something useful. Sufficient has been narrated to indicate that there is no limit to such manifestations of ingenuity. Matter is indestructible. Properly handled, it can be used over and over again. Now that the ball of economy has been set rolling in grim earnest, strenuous endeavours are being made by the thrifty and provident to redeem the English-speaking race from the indictment of being woefully extravagant, with which it has been freely assailed for so many years.

CHAPTER XV

THE LIFTING-MAGNET AS A WASTE DEVELOPING FORCE

WASTE is precarious to handle. The very nature of the material demands that it shall be worked up in the most economical manner. Under the fickle influences normally prevailing upon the market, the margin between profit and loss may suffer such attenuation from inefficient exploitation as to submerge the factor of profit, thus endangering the very practice of utilizing the residue. It is immaterial whether time or labour be the adverse circumstance. The one influence can be quite as ruinous as the other. Should the cumulative effect of the two forces be experienced simultaneously, then the results are almost certain to be devastating and prompt in their action. Consequently, to secure the uttermost benefits attainable it is imperative that the most economical and efficient methods should be employed.

This is particularly the case in the iron and steel trades. The competition between the various nations in this manufacturing field is excitingly keen. It must not be forgotten that, in this industry, waste plays a very prominent part as a raw material. It may be tins rescued from the domestic dust-bin, turnings from the lathe, a worn-out locomotive boiler, or the battered hulk of a steamship snatched from the jaws of the hungry seas through the ingenuity of the salvage engineer.

In the handling of scrap and junk the designing engineer has been strikingly ingenious, resourceful, and free with his expressions of resource. The cranes and other mechanical handling devices, which he has evolved, compel attention

for the simple reason that they have been introduced to secure a reduction in the cost of moving the material. In this direction finality is impossible of attainment; the necessity to reduce the cost factor is so urgent and continuous. Creative effort, thus fostered, has achieved a distinct triumph during the past few years. It has evolved a new system of dealing with iron and steel, especially the waste, which is rapidly displacing all other methods which hitherto have held undisputed sway. I refer to the lifting-magnet.

It was a British mind which first conceived the idea of harnessing the magnet to the wheels of the iron industry. Sir William Sturgeon saw no reason why the toy of our childhood days, the pin-attracting properties of which extended us infinite delight and provoked indescribable wonder, should not be devoted to the movement of ponderous masses of steel. So he made the experiment. But his noteworthy effort proved only partially successful. It did not fulfil expectations, not because the designer was wrong in his deductions, but because he conducted the evolution along fallacious lines. But his failure set men thinking. They followed up his reasonings and discovered why he did not record success. The British pioneer had been content to accept the magnet's familiar form and to reproduce it upon a larger scale to fulfil his objective. This was why he failed. For such as application as he had in his mind's eye a modification in design was imperative. The German and American experimentors, who followed in his footsteps, quickly realized this circumstance and accordingly abandoned the traditional horse-shoe form for a magnet of flat drum-like shape.

In this modernized and materially changed form the lifting-magnet met with instant success. The Germans were the first to recognize its possibilities, and accordingly developed and popularized its utilization in accordance with their characteristic organized methods, with the result that it was not long before all the leading iron- and steel-works of the country were equipped therewith to their distinct commercial advantage.

So far as America and Britain, the home of the lifting-magnet, have been concerned, progress has been slow and uneventful. The Germans set out to reap advantage from

our manufacturing apathy, and to a certain degree succeeded. It remained for the war, with its drain upon cheap labour on the one hand and the necessity to speed up and to increase output on the other, which compelled us to regard the lifting-magnet with enhanced favour. This tendency was accentuated by the urgent requests circulated far and wide to save all waste metal and to turn it over to the country for the production of munitions. In this manner vast quantities of waste metal of every conceivable description were released, which, in turn, led to a demand for handling appliances. Under the conditions which obtained it was imperative that this potential raw material should be handled with the utmost economy, both of time and labour, but native ingenuity had nothing at its command to compare with the lifting-magnet in this connection. Those firms which had been sufficiently enterprising to equip themselves with the German appliance found themselves in an overwhelming superior position, while their lifting-magnets paid for themselves over and over again in the course of a single year.

The national deficiency in supply and its far-reaching adverse effects were remedied through the combined enterprise and initiative of a young electrical engineer and a British manufacturer. The former had followed the German developments very closely and had discovered that, notwithstanding their extravagant claims, these appliances really fell somewhat short of the mark in point of efficiency and economy in operation. Fortified with this knowledge he had promptly designed an appliance of this character, in which the obvious Teuton defects were eliminated, thereby giving a lifting-magnet which represented a decided advance upon the best which Germany could offer.

The Pickett-West lifting-magnet, so named after its designer and manufacturer respectively, is one fully complying with traditional British standards of production, while it also possesses many novel features which have already emphasized their value. It is built along robust lines, so that it completely fulfils the conditions peculiar to its field of application. Moreover, its design can be modified within wide limits to meet the individual requirements of the service for which it is intended, one distinctly ingenious feature being the model fitted with moving fingers,

each of which constitutes a magnet in itself, and wherewith the magnet is able to exercise the maximum magnetic gripping power upon the article for the movement of which it is being used.

Without entering into a technical description of this apparatus it may be said to comprise, in its simplest form, an inverted dish with a central pole-piece. Round this pole-piece is built a coil composed of alternate layers of copper of substantial dimensions and insulating material. The coil is enclosed within the inverted dish and a face-plate is bolted in position. Thus the coil which occupies the whole of the case, with a special insulating compound run in under pressure to occupy all the vacant space such as corners and interstices, is completely encased and safe from tampering. Suitable terminals are fitted and are coupled up to a flexible electric cable through which the current is led to energize the coil and to impart the requisite magnetic energy to the lifting face-plate. When the coil is active, naturally the magnet will readily attract any ferrous metal which it may chance to approach, or with which it may come into contact, and this will continue to cling to the face of the magnet until the current is switched off. The magnet is slung upon the hook of the crane either by chains, or bars forming a tripod terminating in a link. It is applicable to any type of crane, whether it be of the locomotive, jib or derrick type or overhead travelling system, and with equal facility.

The foregoing description is merely a bald description of the lifting-magnet in its simplest form. To secure the highest efficiency many perplexing technical issues had to be resolved. The magnet is necessarily of impressive dimensions and weight, circular or rectangular in regard to the form of the face-plate according to the nature of the work to be fulfilled, and ranging from 24 to 62 inches in diameter. The most popular size is that measuring 52 inches across the face. Massive construction is inevitable to enable the appliance to withstand the rough wear and tear, as well as unceremonious handling, to which it is exposed in the average iron-works by indifferently skilled labour, or to meet the conditions of piece-work when operations are necessarily conducted at relatively high pressure by the men who are bent upon the consummation of one

end—the maximum return in the form of wages for the work accomplished.

Robust construction involves weight. Precisely what this means may be gathered from the fact that the German 52-inch lifting-magnet weighed 3 tons, whereas its British rival, to which I am referring, weighs only 2½ tons and has a 20 per cent. greater lifting capacity, despite the reduction in weight of the magnet itself. The magnet in question will lift from 900 to 33,600 pounds—even more—according to the character of the material to be handled, the lower figure applying to sheet-iron, scrap, and bolts, while the other extreme refers to heavy solid steel ingots or armour-plate.

Precisely why the lifting-magnet should have taken so long to establish its virtues, both in this country and the United States of America, is somewhat inscrutable, especially in the latter country which, as a rule, is disposed to introduce time- and labour-saving appliances with alacrity. No matter from what point of view it may be regarded, it represents the biggest time- and labour-saver as well as money-maker yet introduced into the steel industry.

One reason advanced for its comparatively slow adoption is rather interesting. It was averred that to the men, accustomed as they were to seeing loads slung by chains, the sight of a mass of steel clinging to the face of the magnet by a force which they could not understand verged on the uncanny. They knew little or nothing about magnets except in the form of a toy, and could not understand that sufficiently attractive effort could be exerted to keep the mass adhering to the flat face of metal. The fact that the moment the current was switched off released the load was something equally beyond their comprehension. Forthwith they arraigned the lifting-magnet as dangerous, and, while not openly condemning its use, declined to work in its vicinity. Whether this was so or not has never been fathomed, but it is generally observable that men working with such an appliance observe a wise discretion, and refrain from working or moving beneath it. This very respect for the apparatus has achieved one distinctly valuable result: accidents are few and far between, even in America, in which country respect for human safety is declared to be

at zero, where the handling of huge masses of metal is conducted by the lifting-magnet.

But, eliminating the psychological effect upon the workmen, it is to be feared that employers were slow to visualize its advantages. Certainly in Britain there are many employers, who, notwithstanding the impressive array of figures advanced in its favour, and who have been brought face to face with the economies it is able to effect, still cling tenaciously to antiquated practices.

So far back as 1911 Mr. H. F. Stratton, in drawing the attention of the American Foundrymen's Association to the possibilities of the lifting-magnet, presented some illuminating figures. At that time the American steel industry was handling 10,000,000 tons annually by this system and thereby was saving over £200,000—$1,000,000—a year. So far as scrap was concerned he emphasized the opportunity it presented in this field, because, out of an annual melt of 6,000,000 tons of pig-iron and scrap, from 1,000,000 to 2,000,000 was represented by scrap-iron and steel.

The American railways were among the first to appreciate the possibilities of the system. The Chicago, Rock Island and Pacific Railroad introduced the idea for handling scrap and iron in 1909. Up to that time all scrap had been handled by hand, the cost in and out ranging from 30 to 35 cents—15d. to 17½d. per ton—which, according to the authority cited, could be accepted as applicable to all the railways following such a practice, and to record which figure, be it noted, demanded excellent arrangements and efficient organization. Upon the introduction of the lifting-magnet these costs were immediately cut down to 10 to 12 cents—5d. to 6d.—per ton, in and out, inclusive of every expense, the figure for the actual sorting being only 4 to 7 cents—2d. to 3½d.—per ton. The authorities of this railway stated that unsorted scrap could be unloaded by means of the magnet for 2 to 5 cents—1d. to 2½d.—per ton, while, if the scrap were sorted, the cost came out ½ to 1½ cents—¼d. to ¾d.—per ton! Similar work conducted by hand labour, according to the previous practice, cost about three times as much.

That the experience of this one railroad was not isolated was proved by the experience of the Lake Shore and Michigan

Southern Railroad, which supplied Mr. Stratton with the following comparative figures for other operations incidental to the conduct of its work :—

Loading locomotive tyres by hand	17 cents	(8½d.)
„ „ „ crane with chains	8 „	(4d.)
„ „ „ „ magnet	4 „	(2d.)
„ heavy casting by crane with chains ..	20 „	(10d.)
„ „ „ „ magnet ..	3 „	(1½d.)
„ „ „ hand	almost impossible.	

It will be observed that the handling charges by the magnet were one-half of those by the crane with chains in connection with the locomotive tyres, and one-seventh in the case of the heavy castings, while the advantage over manual effort in the case of the first-named was no less than 32·5 per cent. Little wonder that, during the past nine years, the utilization of the lifting-magnet in connection with the handling of iron and steel in the United States has advanced by huge strides. To-day it constitutes an integral part of the wrecking equipment of every leading American railroad. After the large debris has been cleared up, the lifting-magnet is swept over the ground to pick up nuts, bolts, nails, screws, and any other odds and ends of a ferrous nature which have escaped recovery by the conventional methods.

So far as these islands are concerned, considerable progress has been made during the past five years in regard to its adoption. Extended use has not been confined to the handling of metal in our steel-works, but for the reclamation of iron and steel cargoes which were lost as a result of the German submarine activity. Its employment in the salvage field was suggested as the result of the sinking of a barge carrying ingots of very special steel sunk at the entrance to a port on the East Coast. Although the wreck lay in relatively shallow water, it was speedily discovered that salvage by the orthodox methods would prove somewhat uncertain, owing to the awkward position of the sunken barge and the difficult tidal and other conditions.

The possibility of retrieving the valuable steel by magnet was broached to Mr. F. N. Pickett, the inventor of the British lifting-magnet, to which I have referred. A certain doubt upon the point existed in official circles from the knowledge that the German appliance could not be em-

ployed in such duty, owing to the coil not being impervious to water, which of course nullifies the utilization of the electric current. But the British magnet, being built upon different lines, is watertight, and so the designer expressed complete confidence in his apparatus being suited to the task. The magnet was secured, and divers went down to blow open the side of the barge to permit the magnet to reach the cargo.

The magnet was lowered and was found to work with as much ease and simplicity as under conventional conditions in the steel-works. It was plunged into the hold of the invisible craft, and subsequently the sea-bed on either side was swept therewith. So successfully and completely did it fulfil its unusual task that every ingot was retrieved, and that within a very short time. The sinking of the barge occasioned little damage beyond a slight delay in the delivery of the material, which was valued at £150—$750—per ton. True, the barge was lost, but that was an insignificant disaster, and but poor recompense for the expenditure by the enemy of a torpedo costing possibly £1,000—$5,000.

The success of the magnet in this instance has been responsible for its utilization in other fields of submarine endeavour. A freighter was sunk with a valuable steel cargo aboard. The vessel was examined and found to have settled upon an even keel. Divers descended and opened the hatchways, while sections of the decks were cut away to expose the cargo. The magnet was then brought into action, and the cargo unloaded as readily as if moored alongside the dock. This success in the open sea has been responsible for the salvage of similar cargoes which have been lost around our coasts. So far as the Pickett-West lifting-magnet is concerned, there is no obstacle to its use in this field so long as sufficient swing can be imparted to the suspended apparatus to ensure sweeping of the wreck, and up to the depth corresponding to the pressure of the insulation in the coil drum. Seeing that this is introduced at a pressure of 120 pounds to the square inch, the lifting-magnet can be safely used in water up to a depth of approximately 250 feet without the insulation collapsing under the imposed water-pressure, and this is a depth far beyond that at which a diver can work. But, taking the wrecks

lying within water accessible to the diver, appreciable recovery should be possible.

It is generally conceded, in view of the success which has already been achieved, that there is a promising future for the apparatus in this field so long as it is designed and constructed along correct lines. The cost of operations will be reduced therewith very materially, and the strain imposed upon human effort as represented by the diver will be decreased very markedly. Instead of salvage operations being confined to an hour or two daily, according to the velocity of the tides and currents, it will be possible to continue work during the round twenty-four hours so long as the weather is propitious. The operator will be able to sweep the wreck from end to end, as well as to scavenge the sea-bed by swinging his magnet, confident in the knowledge that magnetic metal will be trapped in the process for haulage to the surface. Even if ships should prove impossible of recovery intact there is nothing to prevent their reclamation piecemeal. Dynamite will reduce the wreck to scrap of weight and size within the lifting capacity of the apparatus, and at the price obtaining for such junk the expedient should prove profitable. So we should be able to retrieve a certain and imposing proportion of the wanton waste incurred by the ruthless attacks of the enemy upon our sea-going traffic.

It has even been suggested that the magnets might be employed to salvage many of the German submarines which we have sunk, more particularly the coastal type of craft. These were relatively small, and for the most part were sunk in comparatively shallow water. In the water-logged condition the dead load to be handled is approximately 800 tons. If desired these craft could be lifted to the surface intact, or, if in pieces, retrieved in sections for sale as scrap. The inventor has elaborated his plans, which involve the suitable disposition of a certain number of magnets over the sunken submarines. He suggests that eight magnets would be adequate for the task. Seeing that each magnet has a pulling power of 250 pounds per square inch of its surface, the aggregate haul which could be brought to bear upon the submerged craft simultaneously by the eight magnets would be at least 1,920 tons, or twice the total weight of the submarine. With such a lifting effort avail-

able it should be possible to drag the wreck from even the extremely tenacious North Sea mud. The question arises, although recovery of such waste is admitted to offer every attraction, as to whether the German submarines are worth the trouble, even if they be sold as scrap. In view of the price which the surrendered boats realized this is extremely doubtful, although experienced salvage engineers admit that even if prevailing scrap prices were obtained the venture would prove profitable, that is in the strict commercial sense.

As a scavenger for magnetic metals the lifting-magnet cannot be excelled. It is far more thorough than hand-labour, and will fulfil its mission more completely than any other mechanically-operated device to this end. Lowered to twenty-four inches of the ground it may be swept, or swung, to and fro in the certain knowledge that any stray scraps of iron and steel will readily jump the intervening space in response to the strong magnetic influence exerted. In this manner a wide area can be completely cleaned of all stray iron and steel fragments, much of which would otherwise be lost within a few moments.

The recognition of the peculiar qualities of magnetic attraction has led to an interesting development which should prove capable of extensive application and to distinct commercial advantage in our steel-works. As is well known, the slag is run off separately to be dumped. But this slag often carries an appreciable quantity of metal in a divided state. Hitherto this has been wasted, but it has been found that, if the slag be broken up, by the aid of a magnet and "skull-cracker" ball, and the magnet be swept over the mass, that the fugitive metal can be retrieved and in sufficient quantities as to render the operation profitable.

For the movement of iron and steel in factories it is difficult to excel. A consignment of kegs of nails, bolts, nuts, screws, or some other small articles requires removal to or from store, or to vehicle. Under normal conditions the practice would be, either to stack them on trolleys or to pack and sling them from cranes, the loading constituting the adverse factor from the appreciable time it takes. If the magnet be used no such preliminaries of any description are necessary. The magnet is merely lowered, the current switched on, and the next moment as many loaded kegs

as can squeeze themselves upon the face of the magnet may be lifted. The attractive effort is sufficient to exert its influence through the covers of the kegs to act upon the metal within. Moreover, if the kegs be small, more than one layer will be found possible of removal at a time, inasmuch as the depth to which the magnetic influence can be exerted—" digging " effort as it is called—has been found to be equal to the diameter of the magnet face.

For handling metal waste in the form of turnings or swarf it is far cheaper and quicker than any other known process. When the magnet is dropped upon a pile of such residue and is then raised, it will tear away a huge chunk of the heap—a ton or more of tousled and ragged ribands of steel jostling and clinging tightly to one another and to the magnet-face like a swarm of bees to the branch of a tree. It will successfully handle, and for no heavier cost, swarf which defies handling by any other means, except at prohibitive expense. At a certain steel-works in the North of England ten tons of matted steel turnings were permitted to stand for several weeks in a railway truck in an open siding. When it was decided to unload the vehicle the turnings were found to have rusted and to have settled down into as tightly packed a heap as could be imagined. The normal practice was for men to shovel such material with their forks into the charging boxes, but they found that they could not force their tools into this formidable heap. The mass was surveyed and the hopelessness of coping promptly therewith was admitted. Under manual labour the job would occupy several days, even if it could be successfully handled at all, upon which point considerable doubt prevailed.

It was decided to try the magnet. It was brought along on its traveller and lowered into the truck. The winding drum was set going, and there was a fearful snapping and snarling. The magnet refused to release its hold, while the metal, being tightly jammed and packed, offered a stiff resistance to the irresistible attraction of the magnet. But, within a few moments, the magnet tore itself free with some 3,360 lb. of the tangled rusted steel clinging to its face. Within six minutes, and by half-a-dozen lifts, the vehicle was cleared of its ten tons of scrap.

While the circular form of magnet is that generally

favoured, variations are made to comply with different requirements. Some articles, such as steel rails, pipes and iron rods, from their distinctive shape, only present an extremely limited surface upon which the magnetic pull can be exerted. As a rule, to enable such articles to be handled with efficiency and speed, two magnets, rectangular in form, and spaced a short distance apart, are used. The magnets are coupled together, but maintained a specific distance apart by spacing bars, while they work in unison. While the area available for contact upon each magnet is somewhat reduced, as compared with the circular type, this deficiency is counterbalanced by the ability to apply the magnetic lifting effort at two points.

It is doubtful whether the true money-saving possibilities of the lifting-magnet are really appreciated. The initial outlay may appear heavy—in the case of the British magnet to which I have referred it ranges from £150 to £600—$750 to $3,000—according to dimensions, face-form and lifting capacity—but this expense is readily recouped. The lifting-magnet is not only a time-saver but it enables given work to be accomplished with fewer men. In some instances this displacement of labour has attained striking proportions. At one steel-works a lifting-magnet of 52-in. diameter was installed at a cost of £400—$2,000. It is employed for handling pig-iron, and in this work has dispensed with fifty men. The saving in wages, which its introduction has rendered possible, sufficed to defray the capital cost of the apparatus during the first three months of its use.

The results recorded at another establishment are equally impressive. A 36-in. magnet was acquired, and for one specific duty—loading trucks—was employed for a total of twenty hours during the month. Previous to its acquisition this work was carried out by manual labour, and it used to demand the combined efforts of ten men for ten hours to load the vehicle, the cost being £4—$20. With the magnet the truck is now loaded in two hours and at a cost of 8s.—$2—this figure being inclusive of all charges—electric current, depreciation, interest, labour, etc. In the course of the year the magnet puts in 240 hours truck-loading, the number of trucks dealt with during this time being 120. The saving effected by the utilization of the magnet is thus £3 12s.—$18—per truck or £437—$2,185—per year. Seeing

that the magnet at the time of its installation cost £150—\$750—it will be seen that it pays for itself approximately three times over in the course of each twelve months, and that upon one single range of duty for an insignificant period of time.

Under manual conditions of handling scrap and at the current contract trade union rate the cost is 1s. 4d.—33 cents—per ton. With the lifting-magnet, including labour and depreciation, the cost is only one penny—2 cents—per ton for this work—a reduction of 1s. 3d.—31 cents—per ton! At the works of the Stobie Steel Company, Dunston-on-Tyne, the initial cost of the lifting-magnet was recovered during the first four months it was used. This company declares that the annual saving which its employment effects is £800—\$4,000.

But the applications of the magnet are not confined to lifting and carrying operations. As an instrument for breaking up masses of steel too large to be handled conveniently, or to be passed into the cupola of the furnace, it cannot be excelled, either in point of efficiency, safety, or economy. Breaking-up is carried out by what is known as the "skull-cracker," which comprises a roughly-cast ball of steel which may weigh as much as 22,400, 27,000 or even 36,000 lb. This is picked up by the magnet and lifted to the desired height. The current is then switched off, releasing the ball to fall and to strike the scrap-boiler or some other cumbrous piece of junk a terrific blow.

While the "skull-cracker" has been in vogue for many years with mechanically operated devices, and so is not peculiar to the magnet, yet this latest development represents the highest achievement yet attained in this particular direction. Under mechanical conditions from four to six men are required to carry out the work successfully. With the magnet and ball the task can be fulfilled by two men—if exigencies so demand it can be completed single-handed by the crane-magnet operator—while the time occupied in such essential destruction is very much less, more efficiently accomplished and with complete safety, because under mechanical conditions breaking-up is generally regarded as highly dangerous work. A further advantage is offered by this system. The "skull-cracker" can be lifted and dropped alternately until the scrap has been

reduced to suitably sized pieces, and then the magnet, disdaining the ball, can pick up the pieces of junk to bear them away to the furnaces without any delay.

Despite the forward strides which have been made in regard to the adoption of the magnet in the British iron and steel trades during the past four years, this system of handling ferrous metals is still in its infancy. It has been neglected far too long. Yet it is a force which in the future must play an increasing important rôle, because it is generally admitted that, to offset the higher wages incidental to production, it is imperative for manufacturers to exploit fully every possible time, labour, and money-saving device. The magnet is one of the most attractive contributory factors to this end, especially in connection with the handling of iron and steel waste, that has yet been contrived.

CHAPTER XVI

RECLAIMING 321,000,000 GALLONS OF LIQUID FUEL FROM COAL

It has been said, doubtless with a good deal of truth, that Britain owes her manufacturing prosperity to her abundant domestic resources of fuel. But, in the exploitation of our coal reserves, we emulate the rat in the corn-bin. We waste quite as much, if not more, than we ever use. The country around our collieries is disfigured with huge dumps, among which are thousands of tons of what is really low-grade fuel. Occasionally a tip-heap will catch fire, to burn sullenly for weeks and months. One such large dump in the United States burned uninterruptedly for years. This would not be possible if there were not present a large volume of combustible matter—coal—associated with the so-called useless material.

The colliery tip-heaps, while formidable in the aggregate, and representing a crushing indictment against our so-called advanced scientific attainments, merely constitute one, and a minor, tangible illustration of the great coal-waste issue. No matter in what direction we may turn in this colossal industry, we find evidences of improvidence and stupendous losses in varying degree.

It is a matter for speculation whether any other raw material is so prolific of residuals as coal. Oil is probably the solitary exception, but then petroleum is closely allied to the solid fuel. But refuse in regard to coal is equally ambiguous. The wastes vary so widely in nature, while each grade of residue possesses its individual possibilities. We are disposed to pride ourselves upon the big strides we have made in our exploitation of these residues but,

as a matter of fact, we have barely touched the Aladdin's lamp which it represents.

To render full justice to the coal-waste issue in all its kaleidoscopic forms would absorb many volumes. The subject is so vast and complex. It is my intention, within the scope of this chapter, to confine myself to one specific substance derived from coal, one which we persistently declined to consider in its real aspect until the fight for national existence applied the sledge-hammer blows to drive into our heads that we were guilty of criminal neglect. Why we should have required this drastic force to compel us to admit our indifference towards a great national asset it is difficult to explain. Our most formidable rival in trade had been sparing no effort for years to achieve an overwhelming industrial triumph therewith and to our discomfiture.

As I have previously remarked, Germany revelled in our junk piles and rubbish-heaps. The French *chiffonnier* never raked over the contents of a Parisian dust-bin more assiduously than did the German rummage among our waste dumps. He was not too proud to bear away what we disdained and rejected. It served as food to maintain the colossal plants, equipped with elaborate and costly machinery, which he laid down. We, on our part, were not backward in paying him, directly and indirectly, to work up our wastes, especially those from coal, and were ever ready to acquire the articles manufactured therefrom and at any price he felt disposed to quote.

While, to a certain degree, we have become wiser in our generation, and are handling our coal resources and the residuals resulting therefrom with less prodigality, we are still woefully improvident in this field. The degree of waste, despite the reforms introduced, has become accentuated essentially because of the increased magnitude of this industry. The blind adherence to typically British methods and ideas has led to some striking anomalies which to other nations must appear almost incredible. For instance, the coming of the high-speed, internal combustion motor emphasized the need for a volatile liquid fuel. Experience proved the hydro-carbon, petrol, to be most eminently adapted to the purpose. But Britain, as every one knows, has so far proved to be as barren of paying petroleum deposits as is

the Sahara of cornfields. So, as we could not produce petrol, we decided to buy it from abroad, and continue to do so to this day.

Yet we need never have bought a single gallon from a foreign country, to keep our huge fleets of motor-omnibuses, taxi-cabs, touring cars, lorries, vans, agricultural tractors, and motor-boats moving. If we were as wideawake as we ought to be we should cease to buy a further pennyworth from beyond the confines of the Empire forthwith, turning the millions sterling we spent annually in this connection into the pockets of our own workers and industries. It would not involve the withdrawal of a single vehicle, and we should have the satisfaction of knowing that we were absolutely independent of the foreigner in a matter of most vital concern to the community—transport.

The domestic analogue to imported petrol is benzol, the volatile hydrocarbon coaxed from our old friend, King Coal. From the motoring point of view this derivative from the mineral fuel is capable of fulfilling every purpose in regard to transport which petrol can or ever will do. Why we still refrain from setting out to recover this spirit to the uttermost ounce, notwithstanding the lessons taught by the war, is beyond comprehension. There are some kinks in British mentality which defy all unravelling. The exploitation of liquid fuel from coal is one of them.

If we turn to the trading figures for the fiscal year 1913 we find that we imported petrol to the extent of 100,588,017 gallons for which we paid £3,803,397—$19,016,985. This money was sent out of the country. Even our Dominions did not reap much benefit from our liberality. Turning to the other side of the account we find that during the self-same period we sold to foreign purchasers 30,415 gallons of motor spirit *made in the United Kingdom*, and valued at £1,420—$7,100! Our delightfully unbusinesslike way of doing things left us £3,801,977—$19,009,885—on the wrong side, when really we ought to have shown a substantial balance in our favour.

Benzol is not only essential to the motor industry, but it is absolutely indispensable to numerous other trades. Without it the vast range of synthetic colours, marketed by the German firms, could never have been attained. Had Germany embarked upon an economic instead of a military

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war she could have forced the whole world into abject surrender within a few months by withholding supplies of these dye-stuffs, medicinal preparations, synthetic drugs, disinfectants, and chemicals. This is borne out by the abnormal prices realized from the sale of the small quantity of dyes which were smuggled across the Atlantic to the United States of America by the commercial submarine *Deutschland*. One small box containing 100 lb. of sky-blue colouring realized £190 or 38s.—$950 or $9.50—a pound! Before the war the self-same dye-stuff could be purchased readily for 2s.—50 cents—a pound.

By making the plunge along industrial lines Germany could have brought our cotton, woollen, silk and other textiles, paper, paint—in short, every trade into which colourings enter—to a dead standstill within a very short time. The United States of America, France, Italy, and other countries would have been forced into a similar condition of stagnation and disaster. Germany, by virtue of her unlimited supplies of these essentials to contemporary industry, would have been in the position to have supplied the whole world—upon her own terms. Fortunately for us, a bloodless victory to secure world-wide domination did not appeal to the Teuton temperament.

The official attitude, so far as this country is concerned, towards the reclamation of the volatile liquid constituent, or waste, from coal has always been one of negation. Contrast this tendency with that obtaining in Germany, which set out to support private enterprise by installing a comprehensive plant upon Government property to win 6,000,000 gallons of benzol a year from state-owned and state-mined coal. The British official attitude is additionally remarkable when it is borne in mind that adequate supplies of this material are absolutely imperative to the maintenance of our national security, because benzol constitutes the backbone of modern high explosives.

The recovery of benzol is every whit as essential to the community of these islands as is the provision of drinking water. It may appear to be Draconic to compel the delivery of the last ounce of benzol from the coal or gas we burn, but there are many other enactments in force of a more exasperating character, and which are productive of extremely little benefit either to the individual or the community.

In this particular instance no one would suffer in any way, because, while the whole trend of scientific thought is towards the thorough recovery of this valuable liquid fuel and industrial weapon, it does not hesitate to demonstrate how the desired end can be obtained without inflicting the slightest hardship upon the citizen.

The steel trade demands huge quantities of coke to conduct its operations. The carbon residue from coal is preferable to the raw mineral fuel. To meet this technical requirement special ovens have had to be evolved to turn the coal into coke. Yet for years we carried out this conversion and allowed the substance thrown off in the process to run to waste. We even continue to do this to-day. It was found that the coke could be obtained more readily and easily, as well as cheaply, by means of what is known as the bee-hive oven. This coke-producer attracted the attention of the interests concerned because it was not only cheap to install but inexpensive to maintain and renew, while it facilitated compliance with the fluctuating demands for the coke which naturally is due to the alternating periods of depression and prosperity in the steel trade. But we have no monument to waste comparable with the bee-hive oven. However, it became so firmly entrenched as to prove wellnigh resistant to progress when science came along with an improved system yielding a coke of equal quality, but which had the additional recommendation of enabling all the other products arising from distillation and which formerly were permitted to escape, to be recovered.

The virtues of the new method were conceded, but the heavier initial expenditure which it entailed was regarded as an insurmountable adverse feature, especially as the Britisher gave expression to another peculiar trait in his character—would the revenue derived from the by-products more than offset the increased costs, capital charges and maintenance expenses? One disturbing factor demanded particularly careful study. When the call for coke declines, and a certain number of the ovens have to be closed down, they cannot be brought into re-activity upon the revival in the steel trade without an overhaul.

In restoring the ovens heavy expense is incurred. The antiquated and wasteful bee-hive oven can be renovated at a trifling price, but the modern by-products recovery

oven entails far heavier expense before the resumption of operations. The charge varies according to the care which has been bestowed upon its maintenance, but, if this has not been conducted along careful lines it may easily incur an expenditure ranging up to 15 per cent. of the original cost of the plant. This charge, unless defrayed out of the renewals account, must be carried to capital. In view of this circumstance the general practice has been to install the by-product system to take care of the constant load—the output of coke to the degree below which it cannot fall even in periods of extreme depression—and to utilize the obsolete bee-hive oven to take care of the fluctuations from the irreducible minimum to the maximum. This margin being extremely wide naturally, the bee-hive still holds sway, and so continues its wasteful reign unchecked.

To extend their field of activity and to provide an outlet for the products of their brains the Germans made an astute commercial move. They expressed their readiness to equip the British coking plants with their modern by-product recovery system on condition that they were to be at liberty to acquire the liquid residual—benzol. The suggestion found certain favour in British eyes. The benzol was a drug on the home market, so its shipment to Germany was regarded as the solution of a perplexing problem. In this manner Germany secured the necessary raw materials from the British scrap-heap to feed her dye industry and to pile up her reserves of high explosives against the day when the gauntlet should be thrown down. There is a tendency in certain quarters to assail the cunning competitor, but are we rather not to blame for our own extreme shortsightedness, lack of initiative, and indolence?

The coking-ovens, however, only absorb a portion of our total output of coal, the annual average of which may be set down at approximately 260,000,000 tons. Subtracting 60,000,000 tons as the export figure, we are left with a round 200,000,000 tons consumed at home. Of this figure a round 100,000,000 tons is consumed during the year in the domestic fire-grate.

We all revel in the blazing fire in our rooms during the winter, but do we reckon on the cost? The volume of heat thrown into the room is but a trifling proportion of that emitted by the glowing coal. The greater part flies up the

chimney, together with all the benzol, ammonia, and other valuable constituents of the fuel. Immense volumes of soot pour forth from the chimneys to pollute the atmosphere, disfigure buildings and monuments, while the damage wrought within the rooms to fabrics, curtains and other embellishments runs into millions sterling during the year.

Could this waste be avoided? Certainly. The domestic fire-grate does not possess a single virtue. It should be scrapped forthwith. Coal, as a household fuel, should be prohibited. It should be carbonized. Coke, when burned under the most advantageous conditions, throws off as much, if not more heat, and can be induced to shed practically the whole thereof into the apartment. As the alternative to coke we might rely exclusively on gas, releasing the whole of the carbon residue, approximately 70 per cent. of which results from the distillation of every ton of coal for industry. If we presume an average of 10,000 cubic feet derivable from every ton of coal, then we find that the 100,000,000 tons burned annually in the household grates would give us 1,000,000,000,000—one billion—cubic feet of gas, the whole of which is at present being lost up the chimney. From this enormous volume of gas, each 10,000 cubic feet of which contains on the average two gallons of benzol capable of reclamation, we could, if we were sufficiently energetic and enterprising, obtain 200,000,000 gallons of benzol—twice the petrol imports for the year 1913. In comparison with what liquid fuel we could derive from our coal the actual 41,000,000 gallons secured to-day certainly appears to be trifling.

Our methods of burning coal in the home, which is appallingly wasteful, is equalled by the general folly investing our system of gas supply, which is equally improvident, simply because we prefer to cling to the obsolete order of things rather than to march with progress. Years ago, to protect gas-consumers, a standard of value was established. The gas had to comply with a certain candle-power standard. The unit thus was one of luminosity. Such a system was satisfactory in days gone by, when the practice was to use a burner and open flame of the fish-tail or bat's-wing shape. Then some method of standardizing gas according to its luminous intensity undoubtedly was imperative.

But judgment of gas by its luminosity with an open burner is effete. It became relegated to the limbo of things that were by the discovery of Welsbach, which effected a complete and wonderful revolution in gas illumination. His invention supplied the means of securing brilliant illumination with heat. This may sound paradoxical, but is readily explained. The particles of the nitrates of the rare earths, thoria and ceria, which enter into the composition of the incandescent gas mantle, will not emit light until they have been raised to a high degree of incandescence. This can only be achieved by using the mantle in conjunction with an atmospheric, or Bunsen, burner.

This invention rendered it no longer necessary for the gas to carry the constituents which contributed to luminosity, among which was benzol. With the mantle they are superfluous: in fact are deleterious. What is required is a gas rich in the constituents contributing to heat. Coal-gas, or as it is more familiarly called, town-gas, is rich in these two essentials. They are hydrogen and methane or marsh-gas. When burned under suitable conditions they are capable of giving off intense heat, and the higher the degree of incandescence to which the rare earths entering into the composition of the mantle can be raised, the more brilliant the illumination.

Consequently the time has arrived when the standardization of gas according to luminous power should be thrown overboard in favour of one based upon calorific value. This was introduced to a certain degree as a temporary expedient during the war, but it should now be made rigid. Signs of awakening to the true state of affairs are apparent. The research committee appointed to investigate this question has recommended that gas should be sold according to its calorific value, and that all gas-consuming appliances should be adapted to the new order of things.

Should legislation be passed endorsing these recommendations it will be possible for further huge quantities of benzol to be recovered from our coal, or rather the gas derived from the volume of coal annually absorbed for gas production. It is the benzol and toluene which impart the luminous intensity to the gas, but which are unnecessary for the production of heat. At the present moment the quantity of benzol reclaimed from the coal absorbed by the gas-works

is approximately 21,000,000 gallons a year—a fraction of what it might be.

We may safely assume that of the 270,000,000 tons of coal we draw from our collieries every year, at least 160,000,000 tons are capable of such treatment as will enable the volatile liquid fuel to be recovered. Upon the basis of two gallons per ton of coal this would represent 320,000,000 gallons of benzol, of which huge quantity all but 41,000,000 gallons are being lost under contemporary conditions. The value of this spirit at the moment may be set down at approximately 2s.—50 cents—per gallon. Thus we are deliberately throwing away £27,900,000—$139,500,000—a year. It is being permitted to vanish into thin air. This figure serves to bring home what the losses arising from the neglect of waste really represent, and also reveals our extraordinary lack of imagination and enterprise.

Were we to recover the whole of the benzol content of coal we should not only be able to satisfy the whole of the needs, aggregating about 150,000,000 gallons a year, of the domestic motor industry, but we should be able to meet the requirements of the other industries to which benzol is indispensable. There would be no need to grow apprehensive concerning our coal-tar dye industry and the manufacture of other products dependent upon materials derived from coal. The British dye industry is in its infancy. At the moment its benzol requirements are modest, being approximately 4,000,000 gallons a year. But it is an industry which, given full opportunity, promises to thrive and to expand amazingly, and so one may safely anticipate that its benzol needs will advance by leaps and bounds.

Moreover, one must not forget that, as yet, benzol itself is but little understood, because it has not received the attention it deserves from the chemist. If we decide to exploit our coal to the extent which prudence dictates, the wizards of the laboratory will be encouraged to embark upon further original research, and it is quite possible that they will reveal other and equally promising applications for the spirit of coal.

While domestic users have not been fully alive to the possibilities of British benzol other countries, notably France, were eager buyers of what we ourselves failed to appreciate.

We need not sacrifice this export trade: rather we should be able to cultivate and to expand it to a very pronounced degree.

In view of the part which benzol played in the war one hopes that the Government will consider the situation in a more enlightened spirit. The circumstance that we might be able to retrieve a round £28,000,000—$140,000,000—a year should offer every inducement towards compulsory modernization of methods in this particular province. Benzol should be made a national issue. To compel the use of coke, instead of coal, in the household, would go a long way to relieve the coking-ovens and other distillation plants of all apprehensions of glut accumulations of coke, and would tend to steady the output of this fuel, as well as to bring about the abolition of the wickedly wasteful bee-hive oven. Our gas standardization system should be overhauled to ensure the sale of gas by its calorific rather than its luminous value. The country might even do worse than to nationalize benzol, taking over the whole of the output as a corollary to the compulsory distillation of all bituminous coal. As the alternative it might undertake to purchase what the trade could not sell, for naval purposes, inasmuch as in the Senior Service the consumption of petroleum oils has reached an impressive figure from the increasing use of oil fuel, practically the whole of which at present has to be imported.

CHAPTER XVII

FERTILIZERS FROM WASTES

NOURISHMENT is as essential to the land as it is to the animal kingdom. This is particularly so in countries, such as the British Isles, where the land has been worked assiduously, year after year, for centuries. The co-relation between fertilizers and crop yields is too obvious to demand other than mere mention. The main problem, in such circumstances, is to secure sufficient quantities of the nutritive constituents necessary, and at a price which shall render their utilization profitable to the farmer, and enable the resultant food products to be brought within the reach of the public at an attractive figure.

The worship of hygiene and the introduction of practices conducing to the enhanced health and welfare of the community have served to deprive the land of a heavy proportion of that food which, under primitive conditions, it freely receives. Furthermore, the contemporary agriculturist is not content with receiving from the land just what Nature, if left to herself, is disposed to contribute. He practises forced or intensive measures, and in so doing naturally accelerates and accentuates the exhaustion of the soil.

In so far as these islands are concerned—it was equally applicable to other countries similarly affected—the stringency in natural manures was aggravated by the acquisition of all available horse-power for the battle-fronts as well as the need to husband straw for military foraging purposes. So, to ensure the safety and yield of his crops, the farmer has been compelled to fall back upon divers substances, natural as well as chemical, or as they are more popularly termed, artificial manures, although the word "artificial" in this interpretation is somewhat ambiguous, seeing that the

materials employed, for the most part, enter into the scheme of Nature.

Under normal conditions British soil was liberally fed with these chemical fertilizers, especially of superphosphate, nitrate of soda, and potash. And for all of these three indispensable soil-foods we were dependent upon foreign sources of supply, which naturally suffered interruption more or less as a result of the outbreak of hostilities. During 1913 we imported 970,185 tons of these manuring agents, for which we paid £3,333,612—$16,668,060. These figures do not include potash, appreciable quantities of which, drawn from the German mines, were used. But, taking the other two materials, phosphate occupied first place in point of quantity with 539,016 tons valued at £874,166—$4,370,830—while the Chilian nitrate claimed premier position in value at £1,490,669—$7,453,345—for which we received 140,926 tons.

Owing to the availability of the foreign manures there was a tendency to turn a blind eye to our own producing capacity in regard to plant-foods of the chemical order. But such an attitude was quite in keeping with the British character; we preferred to pay compliments, in the form of money, to other countries at the expense of our own. With war we learned the folly of our ways and received an awakening, rude but fruitful.

Of the artificial fertilizers essential to plant life we can supply all with the possible exception of the superphosphate, although in this instance we are striving to develop our home resources. Chilian nitrate may be superseded by the atmospheric nitrates: we can derive all the potash we desire by the observance of the necessary care and the lessons which science in its various phases is able to extend. Possibly the results may not be so prolific as when the imported articles are utilized, but this is merely a matter of opinion, and one upon which even experts agree to differ.

Of the domestic contributions to the artificial fertilizer issue, those which have attracted the greatest measure of attention are sulphate of ammonia and basic slag. So far as the first named, of the nitrogenous group, is concerned, a remarkable reversion of opinion is to be recorded. Prior to the war the British farmer, despite the fact that sulphate of ammonia was obtainable in relatively large quantities

from home sources, was not deeply impressed with its plant-feeding value. At all events the domestic consumption was relatively low, 60,000 tons being the maximum amount used in any pre-war year. But what the British yeoman disdained, his foreign contemporary seized with avidity. During 1913 our exports of this waste, or by-product from our gas-works and coking-ovens, totalled 323,054 tons worth £4,390,547—$21,952,735—out of a total export of 704,071 tons of fertilizers valued at £5,745,484—$28,727,420. France and Spain, as well as our sugar-growing Dominions, were our largest customers, the farmers of which were prepared to pay more for this soil stimulator than were their contemporaries at home. But, as a result of experience gained under the stress imposed by war, sulphate of ammonia found greater favour in the eyes of our husbandmen. During 1916 the home consumption increased by 15,000 tons, a further 15,000 tons' improvement was recorded during the first three months of 1917, while for the 1917 season the figure rose to 150,000 tons.

Under normal conditions, in accordance with the law of supply and demand, prices tend to rise coincidentally with the enhanced manifestation of request, but the country took steps to protect the consumer, and at the same time to remunerate the producers adequately. Whereas the pre-war price for this fertilizing agent ranged from £12 10s. to £14—$62.50 to $70—per ton, the war price was officially fixed at £16—$80—per ton. Inasmuch, however, as the controlled quotation included transport and delivery charges, the actual increase in the cost was not appreciable.

But it was the 1917–18 season which revealed the circumstance that the virtues of sulphate of ammonia at last had really gripped the British farmer. From the estimates which were carefully prepared the requirements were set down at 220,000 tons. As a matter of fact they notched 230,000 tons. Thus, in two short years, the consumption of sulphate of ammonia by the hungry soil of Britain was quadrupled, a really startling achievement. The total output of this commodity, both in the solid and liquid forms, reached a round 400,000 tons, and to-day stands at about 460,000 tons. Approximately, one-half of this aggregate is forthcoming from our gas-works and the other half from our coking-ovens and blast-furnaces. During the war the

balance remaining after the needs of agriculture had been met, namely 170,000 tons, was absorbed in the manufacture of munitions. But under restored peace conditions this latter volume will be rendered available for home consumption or export.

Seeing that our pre-war export figure was 323,054 tons a year, it would seem as if we are destined to lose some of our revenue from this trade. Obviously only about 170,000, or at the utmost, 230,000 tons will be available for our foreign customers. It would seem as if we are certain to fall a round 100,000 tons short of their actual needs, which will certainly be equal to the ante-bellum figure. As a matter of fact the demand will probably be much heavier, considering that the land of these customers has been denied this food for nearly five years; at least supplies have only been forthcoming in small and totally inadequate quantities. Moreover, the home demand is rising still, which must tend to attenuate the quantities available for export.

But there is no need for us to grow apprehensive. In another chapter I deal with the benzol question, and illustrate how we might increase our supplies of a home-produced fuel to displace imported petrol. In meeting our domestic benzol requirements we can increase our output of sulphate of ammonia at the same time. The ammonia is the substance which so worried gas engineers during the early days of gas-lighting. Then it was an unmitigated curse: to-day it is a blessing. The actual yield of sulphate of ammonia from a ton of first-class gas-distilling coal may be set down at 18 lb. However, seeing that this varies according to the quality of the coal, I will set this figure at 15 lb., which is distinctly conservative. On this basis, if the whole of the coal burned to sheer waste in the private grates of the country, and which may be set down at 100,000,000 tons under normal conditions, were first carbonized, it would be possible to add at least 700,000 tons to our present output of sulphate of ammonia, which would thus be brought up to approximately 1,160,000 tons a year. This would be quite enough to satisfy the needs of all our customers. But, at the present moment, owing to our supineness, the ammonia and the benzol are being allowed to fly up the chimney. Consequently every person who adheres to the consumption of coal instead of coke, in the open grate, just because a blaze is appreciated,

is doing his or her bit towards the loss, assuming the value of the fertilizing agent at the modest figure of £10 per ton, of £7,000,000—$35,000,000—per annum. Truly we are paying dearly for the gratification of a whim.

Second in popularity among the artificial fertilizers comes basic slag. This is another waste product, being the refuse from our steel-works. It has been allowed to pile up in the vicinity of our blast-furnaces to the detriment and disfigurement of our countryside. But an observant and persevering individual probed these unsightly heaps to discover that they contained a valuable food for plants, and in sufficient quantity to render it remunerative to pulverize the rock-like mass into a fine powder. Forthwith, where phosphatic content was sufficiently favourable, the dumps were taken in hand to be ground up into a flour to be distributed over the soil.

But the story related of sulphate of ammonia was destined to be repeated in connection with basic slag. It found greater favour in the eyes of the foreign farmer than it did with the native yeoman, although in this instance the circumstance that a mistake was being committed was discovered possibly more promptly. In 1913 our exports of phosphatic refuse from our blast-furnaces were 165,100 tons, for which we received £633,034—$3,165,170. The consumption upon our home lands was about the same, so that the total output was a round 330,000 tons a year. Here again, once the possibilities of the fertilizer were driven home, an increased demand set in. From an attitude of indifference British farmers turned to one of clamour. Fortunately, the first rush was met by placing an embargo upon the export of this article, and, in this way, double the quantity was at once secured for native needs.

The demand soon absorbed this extra quantity, and then it became necessary to increase the output of the article. But in this instance the problem was not so readily solved. In the first place the farmer was not disposed to accept this fertilizer when its phosphatic content fell below 25 per cent. But the proportion of phosphate varies widely according to the district whence the ore is forthcoming, as well as the actual smelting process followed. It may range up to as high as 44 per cent. or more; on the other hand it may fall to as low as 12 per cent. or less.

Owing to the comparatively limited demand which prevailed for this article before the war, only comparatively few firms essayed the necessary grinding of the rock-like waste from the blast-furnaces. Again it was by no means an easy matter to maintain the slag to the desired phosphate quality. Another disturbing factor was that the smelting of steel, in common with other industrial process, is in a constant state of transition and improvement. This evolution was found to be affecting the slag very adversely, because the tendency was towards lowering of the phosphoric acid content.

However, it was discovered that, while the available dumps showing a phosphatic content of 25 per cent. or more were severely limited, there were an appreciable number of slag heaps carrying a lower percentage, ranging down to 17 per cent. of the necessary constituent. These were taken in hand to be passed through the grinding mills. Even this contribution proved insufficient. The demand was met only by working heaps of inferior phosphate quality and adjusting the price according to the percentage of the phosphoric acid present, the figure naturally rising as the proportion improved.

The increase in the consumption of basic slag was remarkable. The 1916 figure was double that of 1913, the whole of the 165,000 tons formerly exported being absorbed. Increased producing facilities and the exploitation of a lower grade waste, as already mentioned, served to increase the consumption for 1917 a further 150,000 tons to 500,000 tons, which represented the maximum capacity of the works specializing in this product. But although the latter could not be extended to meet the still rising demand, owing to the difficulties encountered in connection with the provision of machinery, every effort was made to keep supply astride of demand. Many cement works throughout the country had been compelled to cease operations owing to the stoppage of constructional activity and were lying dormant. As these possessed machinery excellently adapted to the preparation and grinding of the slag they were pressed into service, especially for dealing with the lower-grade waste from the blast-furnaces. In this way provision was made for lifting the output to 600,000 tons or more a year.

So far as the superphosphates are concerned the deficiency

experienced in this connection has not been so easy of solution. Our resources in the essential material, so far as is known, are somewhat sparse, while a further problem arose in connection with the sulphuric acid, which was in keen request for other purposes. The issue was met by continuing the importation of the crude rock from the northern coast of Africa, and in this manner we contrived to satisfy our needs. But, during this period, the opportunity was taken to ascertain whether or no there did happen to be any suitable rock or other waste which we were neglecting, inasmuch as the moment war ceased immense quantities of sulphuric acid, then being absorbed for the production of munitions and other military requirements, would be released. Investigation was directed once again to the coprolite beds in the Eastern Counties which were formerly worked to yield artificial manures of this character, but which had been abandoned. They were again taken up, and a domestic superphosphate production industry resuscitated upon a limited scale. But whether under normal trading conditions it will prove remunerative to continue this phase of native activity time alone can prove.

The only remaining fertilizer which was a source of perturbation to the British agricultural industry was potash, which is absolutely essential to certain lands and specific crops. Germany was in the position to dominate this industry throughout the world, and she did not hesitate to wield the power she possessed to her own advantage. In pre-war days we imported about 240,000 tons of this chemical, but the greater part was absorbed by other industries, such as glass-making, to which it is vital. Only about 22,000 tons found their way to the land. Nevertheless, the demand in this, as in other directions, was upwards and prices rose by leaps and bounds, even touching about £60—$300—per ton at one time.

Yet we have virtually solved our potash difficulty, and certainly will be able to meet all farming requirements in connection therewith if we only sustain our initiative. We have an abundance of waste materials whence we might obtain all that we need, but for the most part we have spurned them with disdain. It has been so much easier to procure our requirements from the country across the North Sea, although, in expending money in this direction, we

materially contributed towards the construction of the much-vaunted High Seas Fleet. But when necessity compelled us to cast around to work out our own salvation we encountered many surprises. Germany will doubtless be equally surprised in future when she discovers how little dependence we need place upon her vast resources. During the war potash was in urgent request for munitions, but the demand in this connection will no longer prevail, or, at least, only to a limited extent, thereby allowing commercial and industrial fields to acquire what they need, and at a fair price. We shall be foolish if we allow ourselves to abandon the exploitation of our potash-yielding wastes merely by slavishly clinging to the pre-war price for this commodity, which was about £10—$50—per ton. To do so will be to sacrifice our national security and wealth upon the altar of cheapness.

The wastes capable of being persuaded to yield potash are far more numerous than may possibly be conceived. And this chemical is derivable from some of the least-expected founts. A Yorkshire gentleman, Mr. E. E. Lawson, threw a bundle of banana stalks upon his polished office chair and allowed them to remain there for some time. When he removed the stalks he noticed that the juice exuding from the stalks had played sad havoc with the finish to the furniture. This action pointed to the presence of potash in the juice, and apparently in material quantity to remove the polish so effectively. So he suggested to a chemical friend, Mr. R. H. Ellis, that it might be profitable to analyse the contents of the stalk to ascertain just how much potash it carried. This was done, and the result was somewhat startling, indicating 45·9 per cent. of potash and practically no soda. The subject was then investigated by Dr. A. J. Hanley, of the Agricultural Department of the Leeds University, and his analysis confirmed the former finding. The dried matter of the original banana stalk was found to be as rich in potash as kainit, the popular fertilizer of this class. These investigations sufficed to establish the possibility of extracting 188 lb. of dried matter from a ton of banana stalk containing 13·7 per cent. of potash, or 54 lb. of ash containing 47·5 per cent., or 25 lb. of pure potash.

The yield from the individual ton may seem to be too small to be worth considering. But reflect upon the normal

consumption of bananas in this country! The annual importation ranges from 7,000,000 to 8,000,000 bunches, which represents an equal number of stalks—mere refuse. According to Mr. Ellis, under normal conditions the stalks average a round 4,000 in number weekly in Leeds alone. When stripped, the average weight of the stalk is 4 lb., so that there are 16,000 lb. of stalk wasted every week in the Yorkshire city. Properly treated, about 1,340 lb. of dried matter, rich in potash, could be secured therefrom to feed the land.

Applying the reclamation process to the whole of the country, it should be possible to secure from 28,000,000 to 32,000,000 lb. of banana stalk, giving from 2,350,000 to 2,700,000 lb. of dried matter containing 13·7 per cent. of potash —from 321,000 to 370,000 lb. of potash—during the year. If the stalks were carbonized they would yield from 675,000 to 771,428 lb. of ash containing from 320,000 to 366,000 lb. of pure potash. This may represent but a small fraction of the total agricultural consumption of 22,000 tons per annum, but it would be a contribution from a waste product which now has to suffer destruction with the total loss of all beneficial values. The primary difficulty, of course, would be in connection with the recovery of the stalks, but a reorganization of our selling methods, such as the compulsory return of the denuded stalks to the fruit markets for ultimate bulk collection, would go a long way towards the solution of this problem. The question arises as to whether we should not find it advisable to dispose of all vegetable and fruit waste along individual lines, inasmuch as other refuse of this character contains potash in varying proportions. By the establishment of a small, inexpensive and suitable furnace in the markets for the treatment of all waste it would be possible to recover valuable fertilizing ash in sufficient quantities to allow bagging and sale upon the spot. Such treatment would be no more expensive than that in operation to-day, involving transport to, and combustion in, the destructor.

Tobacco is another product rich in potash, particularly the ash. Here recovery would prove an exceptionally difficult task, but it has been suggested that the conservation of ash and the discarded ends of cigars and cigarettes from clubs, hotels, and other centres possessing smoking-room

amenities might be encouraged. The total during the year would be impressive. Certainly collection from such quarters would not be attended with difficulty, while the price payable for the residue might be made sufficiently attractive as to induce the attendants to garner this residue.

So far as the exploitation of waste for potash content in this country is concerned only one established practice, which is extremely precarious, has ever met with recognition upon a limited scale. This is the extraction of the precious substance from kelp, or *vraic*, to mention two of the names under which the familiar seaweed is known. The treatment of this waste is conducted along crude lines, but it is doubtful whether our available knowledge could suggest a more skilled method. British seaweed does not resemble that recovered off the coasts of Japan and the Pacific seaboard of the United States, where the recovery of potash from this residue from the sea has become an established industry.

Yet Britain need not pay a further penny tribute to Germany. We are able to free ourselves entirely from the German yoke, and can confidently look forward to such a happy state of affairs so long as the steel age reigns. The raw material dumped into the blast-furnaces carries a certain proportion of potash. But it has always been permitted to escape. Being associated with the fine dust it was borne through the flues, a certain proportion being deposited therein, but at least 90 per cent. was irretrievably lost. Threatened famine compelled us to devote attention to the possibility of arresting this fugitive potash, and our efforts have met with success. The furnace flue dust is trapped to be passed through a special plant for further treatment. Previous to the war the economical and fiscal conditions would not have permitted such a practice with profit. The requisite plant is necessarily somewhat costly to install and to operate. Had we decided upon such a course of action the Germans would promptly have forced the process into bankruptcy by resort to price-cutting tactics. The Potash Syndicate was exceedingly powerful, and it never hesitated to wield its power, as the United States of America have every occasion to remember when, a few years ago, it came into conflict with the German Government in regard to inter-trading, and was brought full tilt against the potash ace of trumps. Had we ventured

to dispute the German monopoly by any attempt to exploit our flue-dust we should have upset a pretty kettle of fish and should have been bludgeoned into surrender. It is to be hoped that the authorities will hesitate to play so completely into the enemy's hands again, although this is fortunately very unlikely because the Teuton monopoly has been broken effectively by the restoration of Alsace-Lorraine to France which carries, among other numerous advantages in raw materials, the immense potash deposits which the Germans worked so profitably to their own ends. Still, even this achievement should not dissuade us from continuing to exploit the waste dust recovered from our blast-furnaces. Immense quantities of the essential material are forthcoming, the potash content of which varies from 3 to 13 per cent. As output increases it should be capable of recovery at a decreasing figure and at one which should enable the indispensable product to be placed upon the market at a competitive figure.

The foregoing does not exhaust the list of potash-yielding wastes possible of exploitation. It is recoverable from wool in the washing process; feldspar also contains potash; farmyard manure will yield it in attractive proportions—from 9 to 15 lb. per ton; while liquid manure also carries it to the extent of 40 to 45 lb. per 1,000 gallons. Thus it will be seen that we need never suffer from an actual famine in potash if we but resolve to exploit our wastes to the utmost.

I have referred in a previous chapter to the value of leather waste as a fertilizer. Five years ago we did not pursue this problem along determined lines, mainly because we did not really understand its preparation, while our farmers did not regard the product then marketed with favour. But to-day there is a welcome change both in productive methods and the agricultural attitude. Some large plants for the treatment of the leather waste have been laid down and are being brought into operation. Two distinctive treatments are being followed. In the one instance the curried leather—sheer residue from the boot factories possessing no other possible use—is being submitted to treatment for the extraction of the greases and fats used in the dressing processes. In the second system these fats, owing to their low grade and as yet absence of possible industrial use, are being ignored, although they

disappear for the most part from the product in the course of treatment. Otherwise the two methods are broadly identical. The leather is carbonized and then reduced to a dark greyish powder. In this form it meets with the full approval of the farmer, and, as its nitrogen content is said to range up to 9 per cent., it is meeting with ready disposal, the demand at the present moment being far in excess of supply. At one works an output of 60 tons a week is being recorded, which incidentally indicates the quantity of leather waste incurred in our boot-producing factories.

I have also drawn attention to the extent to which fish scrap is now being treated, and here again highly satisfactory developments are to be narrated, the trade, especially in regard to the production of fertilizer, being in a flourishing condition. Fish guano appeals to the farmer, owing to its high content of ammonia and phosphate which aggregate approximately 20 per cent. At one fish waste reducing factory the output is 20 tons every 24 hours, the plant being run on continuous lines, but arrangements are being completed to double the capacity to secure an output of 40 tons during the 24 hours. Hitherto the farmer has not been completely enamoured of fish manure because in certain instances, notably in the treatment of the oily fish, such as the herring, the grease content, which was as anathema to him, was somewhat heavy. But the perfection of the solvent extraction process which I have described, and whereby the oil contained in the finished fertilizing meal can be reduced to as low as 1 per cent., has completely removed this disability.

As is well known, bone-meal is a popular fertilizer. In this instance, although the fatty content of the crude bones may be high, the processes of degreasing have been advanced to such a stage of perfection as to bring about virtually the total elimination of this objectionable constituent. The fertilizer, if properly prepared, will not carry more than 1 per cent. of grease. The bones undergo a very thorough treatment, because this waste is able to feed several industries.

Sewage is also coming more widely into favour as a fertilizer, as I explain in another chapter, while residues incurred in other ramifications of industry are now being carefully collected instead of being permitted to dissipate into the

air or to pass to the furnaces for combustion. The dust arising from the reduction of woollen rags into shoddy forms an excellent hop manure. Dried blood is another first-class fertilizer—in fact it would be difficult to enumerate all the wastes which can now be profitably exploited for their soil-nourishing values. Speaking broadly, it may be stated that any refuse which, upon investigation, is able to yield 3 or more per cent. of nitrogen demands further examination for the discovery of the cheapest ways and means to reduce it to a fertilizer for sale at an attractive figure. If price be right no apprehensions need be entertained concerning disposal; the farmer will absorb the plant food, to nourish his crops, with eagerness.

CHAPTER XVIII

SAVING THE SEWAGE SLUDGE

In matters pertaining to sanitation and the movement of sewage Great Britain undoubtedly leads the world. There our conquest ends. From that point onwards we can only point to lamentable inefficiency. For instance, the lay-out of the main drainage system of London, undoubtedly the finest illustration of such engineering in the world, has involved a capital expenditure of £12,514,606—$62,573,030. By the provision of enormous conduits and feeders the excrementitious matter from residences, offices, workshops, and factories of the metropolis is borne for miles to central stations. In this manner those natural and trade wastes, construed as being inimical to health, are removed swiftly and hygienically, and we compliment ourselves upon our prowess, which certainly is justifiable so far as it goes.

But when we come to the treatment of this material we fail miserably. At the central station the solid matter, in reality a mud or sludge, is separated from the free liquid. The disposal of the latter offers little or no difficulty. It can be rendered innocuous, and is therefore permitted to resume its part in the scheme of Nature. But the sludge: that is a different proposition. A few figures concerning the situation in regard to London may prove illuminating. Certainly they will serve to demonstrate the magnitude of the volume of this waste. During the year over 100,000,000,000 million gallons of sewage are received from approximately 5,350,000 people occupying 95,000 acres. Each million gallons of sewage yields about 25 tons of sludge. The total quantity of solid matter is approximately 200,000 tons. It costs about 30s.—$7.50—to treat and dispose of each million gallons of raw sewage.

The total yield of sludge exceeds 2,600,000 tons a year. It is an incubus having no ostensible commercial value, so is transferred to vessels to be carried out to sea where it is thrown overboard. Seeing that it costs about £17 13s.—$88—to run each vessel out and back again, and that some 111,000 journeys are made during the year, dumping the sludge costs the ratepayers of London nearly £2,000,000—$10,000,000—a year. The crime incidental to London is repeated throughout the country, and in this way, as Sir William Crookes pointed out, the nation is deliberately discarding 16,000,000 tons of valuable nitrogenous material which, were it subject to proper treatment, might be reclaimed to participate in the nourishment of our broad acres. Estimating the value of this potential fertilizing agent at the modest figure of one ½d.—1 cent—per pound we are, of malice aforethought, throwing away a round £35,000,000—$175,000,000—per annum. But this is not the most disturbing feature. For the most part the sludge, and in the case of seaside towns the crude sewage, is discharged upon potential valuable fishing grounds, to the destruction or infection of the fish, especially shell-fish. Furthermore, one must not imagine because the objectionable and dangerous refuse is abandoned well out to sea its serious dangers are removed. Tides and currents play strange tricks, the result being that much of this filth is thrown back upon the coasts, perhaps at a distant point, to wreak possible havoc.

Civilization breeds a strange fastidiousness. The idea of reclaiming sewage for exploitation is repulsive to the average individual, although he does not turn a hair at the use of the comparative material derived from the animal kingdom for the nourishment of the soil, and the feeding of produce cultivated essentially for the table. The argument often raised against any exploitation of excrement is that it has become associated with many other deleterious substances, which have been thrown or allowed to run down the drain, as the readiest avenue for their disposal. But the very circumstance that such waste has become compounded with other residues, many of which are worth reclamation, should be sufficient to induce us to regard sewage not as an incubus or danger, but as a mine worthy of development to its fullest extent.

Fortunately, the objection to the exploitation of sewage

for its commercial contents is in process of being over-ruled by the growth of a more enlightened attitude towards the whole issue, although it is to be feared, in accordance with the precept that what the eye does not see the heart does not grieve, the more progressive policy is being sanctioned unconsciously. It is safe to assert that, but for the war, which retarded the hands of progress very pronouncedly, the new movement in regard to the handling of this material would have made a material advance. Even to-day the outlook is not hopeless, inasmuch as the accentuated need to make every use possible of waste products may result in the sewage exploitation problem being attacked with enhanced energy.

What can be done with sewage is revealed by the action of one or two towns which have taken their courage into their own hands, notably Bradford and Oldham. In these two instances the modern handling of sewage was assumed before the war, so that the experience gathered during the past six years may prove sufficiently convincing to permit the whole subject to be attacked more in consonance with contemporary thought, which views all wastes in one light —potential raw materials for other industries.

Changing conditions and the need to cope with this residue along more comprehensive lines, in accordance with the growth of the population and the quantity of material to be handled, were responsible for the change from the old method to the new in both instances. In the case of Bradford the Corporation found it necessary to establish new works about six miles distant from the centre of the city, and was faced with the necessity to expend £1,250,000 —$6,250,000—in connection with the undertaking. In view of such a heavy capital committal perhaps it was only logical to consider the possibility of rendering the sewage more remunerative in the future than it had been in the past. Any revenue to be derived from exploitation in such a field must react to the advantage of the community affected, more especially when such action does not jeopardize the health of the citizens to the slightest degree.

Of course, the situation in so far as it concerns Bradford was somewhat unusual. The city is the hub of the wool-scouring trade of the country, and in treating the sewage much of the wealth allowed to slip down the drains from

cleaning the wool is open to reclamation. The one great mistake, if such it may be called, of which Bradford has been guilty, in view of the volume of grease contained in the effluents, is ever to have permitted these wastes to pass into the drains and sewers. They should have been collected and treated as a separate entity. But, as this would have entailed combination of the interests concerned, an admittedly difficult undertaking under voluntary conditions, the city authorities decided to repair the sins of omission upon the part of its industrial citizens and to assume the recovery of the valuable materials which were being allowed to escape.

This manifestation of commendable enterprise and initiative owes its origin mainly to the activity of Mr. Joseph Garfield, A.M.I.C.E., the sewage engineer. Many years ago the idea of turning the sewage of the city to industrial account occurred to him, and he embarked upon a prolonged series of exhaustive experiments. These were sufficiently conclusive and sufficiently promising of profit as to persuade the adoption of the methods he advocated at the critical moment, which arrived when the provision of a new sewage station became imperative.

The plant for dealing with the sludge was moved from the old situation to new buildings specially erected for the purpose at Esholt, and the raw material is fed to the latter station through a special main. The sludge contains only 80 per cent. of water, the free water having been previously removed by settling. It is fed into the main by compressed air. Upon its arrival at the station the sludge is lifted, also by compressed air, into large vats, where it is heated by the waste steam from the engines of the power plant. In this heated condition the sludge passes into close-sealed vessels from which, still at a temperature approaching boiling point, it is forced by compressed air through the filter presses. Each of these presses, of which there are about 100 disposed in rows, contains 47 chambers, each 3 feet square.

As already stated, the sewage of Bradford is heavily charged with grease resulting from wool-washing and other industries, and it is this heavy proportion of grease which renders the process so attractive. Moreover, by keeping the sludge in a heated condition during the pressing process the expression of the fatty content is more readily effected.

From 40 to 48 hours are required to fill a press with residuum, that is to say this period of time must elapse before the whole of the available space within the press is occupied by the dry cake from which the grease has been expressed, by which time from four to five tons of sludge have been passed through. Each cake is 3 feet square by 1½ inches thick and weighs about 30 cwt. The grease and water which is driven out of the sludge is carried away from the presses into tanks. Here the water and grease are separated, the water to be re-discharged into the sewage, while the grease is led to the purification tanks. Subsequently the fat is either drawn off into barrels or is pumped into tank wagons for dispatch to the works where it is worked up into articles of commerce, including soap. The oil is found to yield three valuable products—olein, stearine, and pitch. The two last named enter extensively into the dressing of leather, as well as the manufacture of candles and as an insulator for electric cables, respectively.

The installation yields from 12 to 15 tons of grease throughout the twenty-four hours, working, of course, being continuous. This product in the days before the war commanded from £8 to £10—$40 to $50—per ton, but the price is now higher. The sludge-cakes find favour as a fertilizer, mainly from the fact that they are free from lime and carry only from 28 per cent. to 30 per cent. of moisture. This residue fetched from 3s.—75 cents—upwards per ton at the works in pre-war days, when a healthy export was recorded, the product being shipped in appreciable quantities to France and even to the Southern States of America. The output of cake averages from 50 to 60 tons per day. In addition to proving useful as a fertilizer it has been found to furnish, when blended with coal-dust, a serviceable fuel.

The revenue derived from this example of sewage industry is certainly such as to attract widespread attention. In the early days of the process, when only two presses were maintained to establish its possibilities, the grease sales reached £222 10s. 6d.—$1,112.62—per annum. In 1911 the annual revenue had risen to a figure ranging between £20,000 and £30,000—$100,000 and $150,000—from the enlarged battery of presses. When the new works were opened it was anticipated that the Corporation would be

deriving £50,000—$250,000—a year from the sale of the products derived from its sewage upon the attainment of the designed maximum output. Up to the year 1911 the total sales amounted to no less than £100,000—$500,000. From the recital of these figures it must be conceded that Bradford has a very profitable commercial enterprise in its sewage works.

Yet even the foregoing figures are undoubtedly capable of improvement owing to the advances made in the whole issue of the recovery of fats from wastes. The pressing system, even when conducted along the most modern lines with up-to-date plant, leaves much to be desired in point of yield. Under the most favourable pressing conditions at least 10 per cent. of the original volume of grease is left in the residue. The presence of this grease reacts against the value of the residue as a fertilizer, grease being the bugbear of the farmer. With the latest process for grease extraction this content can be reduced down to 1 per cent. Not only does this represent an increased yield of 9 per cent. of fat with its attendant enhanced financial return, but it gives a fertilizer which, being exceedingly low in fat, appeals more strongly to the farmer, and accordingly is able to command a higher price. This fact appears to have become appreciated by the Bradford authorities according to recent developments.

Because such a striking success has been recorded at Bradford, it is not to say that the self-same method would be equally profitable at other places, especially those handling what might be termed purely domestic sewage. The conditions existing at the Yorkshire city are peculiar, owing to the wool-washing trade. The process which is more likely to make the widest appeal, being the one adapted to meet the average conditions, is that which has been installed in the borough of Oldham. This is the invention of Mr. J. Grossmann, M.A., Ph.D., F.I.C., the well-known chemical engineer, who has made the exploitation of sewage his life-long study. The plant in question was laid down in 1912, being set in operation in October of that year, since which date it has been working without a break, giving the most satisfactory results. At the time the installation was carried out the population of the borough was 148,840, and both the water-carriage and sanitary-pan system were in vogue,

although the latter was giving way to the former method at the rate of about one thousand per year. As the conversion system was carried into effect the quantity of sludge which the sewage works were called upon to handle increased, the quantity pressed in 1911 being nearly 8,000 tons a year as compared with 4,000 tons in 1899. This did not include the several hundred tons which were dealt with in lagoons without pressing. As the quantities of pressed sludge increased so did the difficulty of disposing thereof.

The outlook was somewhat disconcerting. The agricultural land in the vicinity could only absorb a portion of the available volume. The necessity to incur the expense of carrying the residue a considerable distance to dispose of it, which solution would have proved somewhat costly, appeared to be inevitable. Experiments innumerable were carried out, but to no purpose. Agriculture, which is regarded as the obvious outlet for such material, was adverse to the proposal to absorb the accumulation for the land, because it carried approximately 15 per cent. of grease. The only escape from the dilemma appeared to be the installation of further presses with the attendant expense for auxiliaries to yield a dry material, and then to pay for the cartage of this residue to some convenient tipping ground or carriage of the settled sludge to sea to be dumped. As a round 30,000 tons of sludge would have been involved, the sea-dumping expedient would have been extremely costly. Further consideration of the question established the possibility of converting the material into a marketable manure, but this would have required the utilization of a trade process and also would have incurred expense.

At this juncture the attention of the Corporation was attracted to Dr. Grossmann's process. It was investigated and submitted to searching experiments spread over a period of three years at the sewage works. From the results obtained and the experience gathered, it gave promise of being completely successful when conducted upon a large scale. So it was adopted.

The Grossmann process may be said to represent the most logical exploitation of sewage yet attempted in accordance with the severe hygienic conditions imposed to-day. Curiously enough, when the disposal of sewage by water-carriage was first introduced, the critics of the principle

did not hesitate to point out that it represented the most wasteful solution of the problem which had ever been accepted for practice. But against these contentions the advocates of the idea urged that the hygienic advantages to be gained were so overwhelming that the question should not be considered from the commercial view-point at all.

Other days, other manners. In this instance, however, not many years passed before the issue attracted such widespread attention as to demand searching investigation, the difficulty and cost attending the disposal of the sludge being responsible for a pronounced outcry against the method. The sludge problem was thoroughly probed by a Royal Commission, by which the opinion was expressed that the value of this waste, calculated upon the volume of dry substance contained therein, was no more than 10s.—$2.50—per ton at the very outside. But as the sludge is produced in a form showing a high percentage of water it was hopeless to expect farmers to absorb it, owing to the transport charges involved for such a comparatively low manurial return, unless their land happened to be situate close to the centres of production. To overcome the water difficulty attempts were made to dry the sludge, in the effort to reduce its bulk, but it was discovered that drying did not constitute a complete sterilization process, with the result that the material was liable to carry infection. But the greatest objection to drying is that this very process, while it achieves one end—the transport difficulty—provokes another disability. The sewage is worth less after drying than in the saturated form.

The presence of fat in material quantities has always been responsible for agricultural hostility towards this waste as a fertilizer. The fat is due to soap used in the household, and which is thrown down the drains, as well as the grease resulting from other domestic operations. The great objection to grease is that it has the tendency to clog the soil.

In turn efforts were made to dispose of the nuisance as a fuel, the heavy proportion of oil present in the dried cake being the attractive feature prompting this application. This recommendation found scanty favour. Another brilliant mind conceived the idea of consuming the refuse in gas-producers, thus obtaining a low-grade gas for power purposes. This attempt failed to meet approbation. A third

expedient was its conversion into an illuminating gas, but this likewise failed to overcome the obstacle. In so far as lighting is concerned, in many places the practice is followed of allowing the gas thrown off by the decomposing fæcal matter during its passage through the sewers, to be led to the burners of adjacent street lamps to mix with the ordinary town gas and thus be consumed. But this is merely a safety precaution; it is not followed from economical motives. Now that electricity is widely displacing gas for street illumination, even this quasi-utilitarian system is meeting with defeat.

Under the Grossmann system, as practised at Oldham, the sludge is subjected to a complete scientific treatment. The process is continuous and automatic throughout. Moreover, the plant is designed and built upon the unit principle, which allows the standardization of parts and ability to meet any desired demand by merely acquiring a sufficient number of units to comply with the sewage resulting from a given population. Each unit is capable of dealing with sludge arising from the purely domestic sewage of 20,000 inhabitants. Thus a town of 100,000 inhabitants would require 5 units, a city of one million souls 50 units, and so on in arithmetical progression. Furthermore, any number of units can be worked together, so that in those centres where the population fluctuates according to season or other conditions, a certain number of units can be shut down during the off period.

The sludge passes to a special tank and is permitted to settle down to approximately 20 per cent. solid matter. It is then scooped up by bucket elevators to be lifted and discharged into another tank at the top of the building. This acts as the storage tank or hopper, whence it is moved automatically by means of screw conveyors and distributed among six hoppers. Each of these hoppers feeds a drying machine. The driers, set out in pairs with their brickwork casings and flues, occupy the upper room. The machines themselves comprise iron cylinders set in the brickwork and coal-fired furnaces. They are fitted with a specially designed gearing and pulley mechanism which gradually moves the crude wet sludge from the inlet towards the opposite end or outlet. Being exposed to heat during this passage the sludge is naturally deprived of the water it

contains, this being evaporated to be led to the furnace where any offensive gases and other matter associated therewith in suspension are consumed before passing to the chimney to escape into the outer air. By the time the sludge reaches the outlet it has been completely dried.

The arrangement of the feed from the hopper to the drier is such that only a measured quantity of sludge can be passed through in a given time, which ensures the condition of the sludge at the outlet being uniform. The provision of a similar measuring system at the outlet of the drier ensures only a measured quantity of sludge being discharged at that point. It will be observed that these protective devices guard against forcing the apparatus to the detriment of the delivered sludge which emerges from the drier in the form of a dry powder.

If desired this residue may be burned. Mixed with coke it forms an excellent fuel, and can be employed towards raising the requisite steam to conduct the treatment of further sewage. But, in view of the fact that this powder contains about 15 per cent. of fat, its disposal as a fuel would constitute about the most wasteful conceivable. Accordingly, the next stage is the extraction of the fatty content. As it comes from the drying apparatus the sludge is passed automatically into a distilling retort which is bricked-in and heated. Above this retort is a tank containing acid, a certain quantity of which is passed into the retort to be automatically mixed with the powdered sludge. Simultaneously superheated steam is driven through the mass in such a manner as to permeate the whole. The interior of the retort is fitted with gearing and pulleys similar to those provided to the drier and for a similar purpose—the steady gradual movement of the sludge from one end to the other. By the time it has reached the outlet from the machine the sludge, completely deprived of fat, is automatically discharged as a valuable manure and is ready for distribution upon the land.

The superheated steam charged with the grease is passed into a condenser, where water from a feed tank condenses the water and throws down the grease. The mixture of condensed steam and grease is passed into a recovery tank. The grease settling out on the top is removed for boiling up in a separate vessel, upon the completion of which treatment

it is ready for packing and sale. The fatty matter consists largely of stearine and palmitine, which to-day meet with a prompt sale at lucrative prices.

But it is the solid residue in the dry powdered form which attracts the greatest measure of attention. Disposal of the grease from sewage has never occasioned so much difficulty as the utilization of the ultimate residue from reasons already explained. In this particular instance the great problem has been solved. The manure is in the form of a fine powder, containing nitrogen, phosphoric acid, and potash, as well as about 40 per cent. of organic material. It is very fine, brownish in colour, odourless, and what is more to the point, absolutely innocuous, having been completely sterilized. Consequently there is no risk of infection being disseminated by its use.

The circumstance that the process is absolutely automatic from the time the sludge is charged into the hopper to the finished article issuing from the distilling retort, is a distinct recommendation. Not only does it conduce to extremely economical operation, but it reduces the necessity to bring human labour into one of the most offensive of industries, inasmuch as the atmosphere of such an establishment is scarcely fragrant, as may well be imagined, although familiarity breeds strange contempts. The only labour essential is that required for heating up the drying machines and retorts.

There is one overwhelming advantage incidental to this process which cannot fail to arouse attention. Pressing in any form is eliminated. This not only signifies a very pronounced saving in capital expenditure in the first instance, but contributes to lower working charges, while there is an enchanced recovery of grease and an absolutely grease-free residue.

Before the Corporation of Oldham decided to install this system upon a practical scale searching experiments were conducted with the resultant manure, to determine its plant-feeding value. It was the promise of being able to find such a ready market for the ultimate residue which constituted one of the attractions of the process. Experiments were conducted at several farms with various produce, and these proved that the manure gives remarkably good results and is more effective than any other plant-feeder

containing the same proportion of nitrogen, potash, and phosphates. Finally it contains an ingredient which is absolutely missing from every chemical fertilizer. The latter is certainly a plant food, but it is imperative that the ground should be treated with a certain quantity of organic matter to assure the physical and mechanical working of the soil. Decaying organic matter fulfils this end admirably, as one would suppose, being a natural process, but during the past five years the bestowal of sufficient quantities of necessary humus has been impossible, owing to the shortage in supplies of farmyard manure.

For this reason every farmer regards a grease-free manure carrying substance of a humus-like nature for the improvement of his soil with a particularly friendly eye, and he is prepared to pay a good price for such an article. The sewage sludge fertilizer prepared under the Grossmann process offers the agriculturist just what he desires in this connection, inasmuch as it carries about 30 per cent. of the humus-like substance. Then, again, the active manurial ingredients are distributed over the mass in such a fine state of division as cannot possibly be attained by resort to mechanical grinding. Finally, it is excellently balanced, and the farmer keenly appreciates a well-balanced fertilizer. Here he gets it because the essential operation has been conducted by Nature, whose process cannot be rivalled. Applied to gardens this manure is found to prevent the growth of yellow leaves, while the green of the foliage is particularly rich and dark. In some quarters there has been a certain degree of hesitation to utilize the fertilizer merely because it is derived from sewage, owing to the prevalence of many fallacious notions. Its origin is regarded with revulsion, and its utilization with a certain degree of dread, but there need be no apprehensions whatever concerning its use. The fact that in the course of the treatment the material is raised to a temperature approaching 600 degrees Fahrenheit—where the superheated steam comes into contact with the waste to expel the fat—effectively disposes of all germ life inimical to the health of both animals and human beings, while it is also clean to handle and odourless, it being impossible, from mere cursory examination of the fertilizer, for the lay mind to determine its origin. Finally, it may be stored for any length of time without creating a nuisance, or deteriorating.

The whole of the output from the Oldham sewage works, which, owing to the process of concentration, is really limited, notwithstanding the volume of crude sewage handled, is readily absorbed by farmers. Disposal was entrusted to a firm to act as the selling agents for the Corporation. Owing to the number of repeat orders received, year after year, this house declares that it could easily place 20,000 tons of the fertilizer, were it forthcoming, without increasing its present staff of travellers.

While the outbreak of hostilities militated against the expansion of the process, although many other Corporations have expressed their readiness to introduce the process into their respective sewage works, the past five years have not been allowed to represent dead time. Improvement upon improvement has been incorporated with the object of securing still higher efficiency. In this direction the inventor has made many distinct progressive strides. The one objection levied against the process was the heavy expense incurred in regard to fuel charges for drying the sludge, and these costs naturally have become accentuated by the 200 to 300 per cent. rise in the price of coal. But in this direction it is now possible to record noticeable reductions.

As a result of experiment the inventor has evolved a new method for settling the sludge. He found that, by adding a very slight amount of sulphuric acid—about 1 part to 1,000—to the sludge coming from the settling tanks, the usual settling process is completely reversed. Instead of the sludge settling to the bottom, the addition of the acid causes it to rise to the surface, and in a much more concentrated form. The water settles to the bottom in a clearer condition and can be drawn off. By further settling and draining this top layer—virtually a thick scum—a sludge can be obtained carrying about 30 per cent. solid matter, and therefore as a less volume of water needs to be evaporated a considerable saving in the consumption of fuel and cost of drying is achieved.

Moreover, it is suggested that in laying down new installations, it will be possible and profitable to install a destructor upon the sewage works. In such cases it would be feasible to draw upon the waste heat from the destructor to conduct the drying and other operations demanding the application

of heat. In combining the destructor with the sewage plant the question of transport of the refuse from the collecting ground to the destructor would demand very careful consideration when horse haulage is employed, but with mechanical traction the question of an extra mile or two in distance hauled is not of such moment, especially as it would be off-set by the saving of fuel which would attend the diversion of the waste heat to this useful application. In fact, in cases where new lay-outs are being contemplated it is a matter for serious reflection as to whether it would not be found profitable to centralize destructor, electric generating station and Grossmann sewage treatment plant in one centralized spot, interlocking them together, and taking full advantage of such inter-connection. The destructor would furnish the necessary steam from the combustion of cinders and other refuse which it does not pay at present to exploit, or preferably other low-grade fuel to drive the electric plant, the waste steam being carried to the sewage works for the drying and other machines together with the desired proportion of live steam, while the electric station would furnish the requisite power for operating the automatic mechanical appliances.

The grease recovered from the sewage, which is of a domestic character, is essentially that from soap, cooking and washing operations. It is totally free from all objectionable smell. It can be purified very easily and is of distinct value. In its crude condition the fat contains about 70 per cent. of stearic acid.

During the past few years the dry powdered residue has not only been utilized in a direct form, but has also been exploited in the production of compounded fertilizers. Mixed with phosphates, sulphate of ammonia, and other nitrogenous products it has yielded a manure which has given most excellent results in farming. Considerable improvements with regard to greater efficiency and cheaper production have been made in the manufacture of compounded fertilizers from this residue, and there is every indication that still greater developments are possible in this direction.

Were all the sewage of this country treated along these lines British agriculture would derive distinct benefit, while industry would also be presented with a new source of supply

of essential raw material. It would go a long way to enable us to use our greases over and over again, because the drain is the most popular avenue for the escape of this material. Sewage represents the greatest waste incidental to this country. Dr. Grossmann estimates its value at approximately £22,000,000 — $110,000,000 — per annum, of which but only an infinitesimal fraction is at present recovered. The value of the fat alone thrown down our drains, and reclaimed in a marketable form would realize from £500,000 to £1,000,000—$2,500,000 to $5,000,000—a year. The value of the manurial product, of which at least 1,000,000 tons are recoverable during the twelve months, may be set down at least at £2,000,000—$10,000,000—the contents thereof being equivalent to 50,000 tons of phosphates, 50,000 tons of potash salts, with nitrogen equal to that forthcoming from 100,000 tons of sulphate of ammonia. This manure would suffice for the fertilization of at least 3,000,000 acres of land from which we might safely anticipate gathering, at a modest estimate, additional crops worth £5,000,000 —$25,000,000.

There is one other fact which deserves mention. Sewage is eminently adapted to the feeding of sandy soils and other land which, at the moment, is considered too poor for agricultural purposes. If this manure were reserved for such land many thousand additional acres might be brought under cultivation in these islands. At the present moment these acres are being allowed to run to seed, constituting what we erroneously term waste land, but only waste because we are not sufficiently enterprising and energetic to reclaim it.

From the point of view of the towns and cities called upon to handle the sewage, the Grossmann process holds out many inducements. It complies with the demands of sanitation because it precipitates no nuisance. It is the most hygienic process yet evolved for the disposal of sewage sludge. The revenue derived from the sale of the by-products—manure and grease—is such as to render the operation of the plant not only self-supporting but money-making. As a rule the sewage works of the average town represent a sink in more senses than one, more especially when it becomes incumbent to resort to the tipping, dumping or other disposal of the enormous accumulations of the sludge. But signs of awakening are apparent. The Oldham

plant has been investigated by Corporations and other authorities, not only of this country but from other parts of the world, who have been satisfied as to its commercial practicability. With the restoration of normal trading conditions it is anticipated that the process will become more extensively adopted, especially as during the past five years ceaseless effort has been devoted to the perfection of details to assure the establishment of the process upon a firm commercial basis.

CHAPTER XIX

HOUSE-BUILDING WITH WASTES

Of the many problems of the day demanding prompt settlement, none, perhaps, is so vital to the welfare of the community as the provision of increased housing accommodation. The issue is by no means confined to Great Britain; it is incidental more or less to every country. Such a state of affairs is not surprising, seeing that building operations, at least in the domestic sense, have been reduced to a condition of comparative stagnation for five years. Even those countries which were not drawn into the actual fighting arena have been unable to carry out housing schemes to meet the needs of their growing populations owing, primarily, to the dearth of the necessary materials and the enhanced labour charges.

So far as Britain is concerned the outlook is decidedly disquieting. It is estimated that at least 1,000,000 houses are required to meet the needs of the population. As a first instalment it is proposed to complete forthwith 300,000 houses, but, here again, experience is proving it to be far easier to adumbrate such comprehensive schemes on paper than to carry them into expeditious effect. Questions of cost have arisen. This constitutes the vital factor, because obviously it is folly to build houses for people who cannot afford to live in them. And the limit in the upward tendency has by no means been attained.

The critical situation has been surveyed from every ostensible angle without any practical solution being found. But have we not been circumscribed in our attacks upon the problem? Have we not become so deeply rutted in our ideas concerning everything pertaining to housing as to be unable to regard the aspect from a totally new point

of view? Similar crises have developed in, and are constantly assailing, other industries. Upon their occurrence they appear to be equally impossible of successful adjustment, but, finally, as a result of attacking a difficulty from quite a new angle and in a new way, it has been not only subjugated satisfactorily, but a distinct improvement upon the old method brought into operation at one and the same time. A new line of thought and development, possessing greater and more economic possibilities, has been opened up to the advantage of one and all. As a rule one need never hesitate to abandon the existing for something new, because the former is generally associated with some form of waste which has become so heavy as to act as a drag. Directly this retarding force is eliminated, or turned to account, a new era commences.

The contemporary situation in the building trade recalls the state of affairs which arose in American agricultural circles as a result of the outbreak of the Civil War. The drainage of man-power from the land precipitated an extremely depressing outlook. Farmers protested that the soil must run to seed from lack of labour to wield the tools. But thinking men held a contrary opinion. Farming had been conducted along lines which had been followed slavishly for centuries. Manual labour had attained undisputed sway and to decisive disadvantage. Why not dispense with hand labour and use machines? The suggestion that mechanism could displace brawn upon the land provoked a good deal of hostile criticism and humour. But the imaginative were not to be dismayed by conservatism, prejudice, or ridicule. They continued perseveringly along their particular lines of reasoning.

What was the result? McCormick introduced the self-binder which revolutionized harvesting methods, while other brilliant minds conceived equally striking time- and labour-saving appliances for other agricultural duties. They not only solved the immediate crisis but imparted quite a new prospect to agriculture the whole world over. It is safe to assert that, but for the introduction of the self-binder, one-half of the United States would still have remained as barren as the wilderness from sheer lack of labour to cultivate it.

If such a complete revolution proved possible of attainment in such an ancient, rutted, and indispensable industry

as agriculture, surely it is not hopeless to anticipate the fulfilment of a similar complete transformation in the craft of house-building? So far as farming is concerned there is every excuse for hesitating to depart from the proved and trusty. A false step may wreak untold harm, but so far as house-building is concerned no such calamity need be apprehended. A mistake can speedily be rectified. It is safe to assert that there is no other line of activity, especially in Great Britain, so closely identified with the effete and wasteful as house-building. In so far as constructional methods are concerned we have scarcely changed our ways since bricks were first brought into use.

We must ruthlessly scrap the old, which has obtained for so long, in favour of the new. Science is forcing the pace, and she will no more be arrested by obsolete theories and arguments than the tides will be held up by a child's spade. Already she is asserting her power. Contemporary methods are wickedly extravagant, and it is this absurd wastage which is primarily responsible for enhanced costs. The ways of science are inscrutable, but they are sure none the less: the first indications of chafing at delay always assert themselves in the traditional becoming too expensive to maintain. The pocket is the positive road to reform; assail its contents, and the world commences to bestir itself. As the farmer, raised in the old school, had to give way to the engineer, so must our conceptions and ideas pertaining to providing houses for the community undergo a complete change. The architect, his numerous satellites, and the cumbrous rules and regulations which have been framed to protect their vested interests must be jettisoned without a thought of regret. The day has dawned when the engineer must assume the responsibility for providing the people with residential accommodation, and he will be assisted by a new force, including the chemist, which will play a far more prominent part in this problem than many may be disposed to imagine.

This is a utilitarian age. People desire houses to live in—not to look at, although every one will readily agree that a certain regard must be paid to external æsthetic considerations. The average house-owner troubles his head very little over the outside appearance of his domicile or the materials of which it is built, so long as the interior offers him all he

desires in regard to comfort and health. Too long have we clung tenaciously to specific theories which are no more adapted to this age than is the slave-oared galley to mercantile traffic. They are destructive rather than constructive. For a time such clock-arresting dogma and precepts hold sway, but sooner or later the pendulum of progress gives such a vicious kick as to break down the whole of the obstructions disputing advance, to assume rhythmic running in a new channel to the advantage of one and all.

Science has the solution to the housing problem ready for immediate application, but she must be allowed to pursue her progressive way untrammelled. From what one might be able to assume, brick and stone represent the only building materials at our command. But are they? In other fields, where restraining forces are not allowed to secure the upper hand, huge forward strides are being made and with a material we, as a supposed commercial nation, have scarcely noticed.

I refer to concrete. We have only to turn to the engineering world to see what has been achieved with this material in the construction of bridges, tunnels, piers, harbours, breakwaters, warehouses, lighthouses, and even ships. If we turn to the United States and Germany we are able to see how we have lagged. In both those countries enormous strides have been made and incidentally, in the prosecution of this task, other magnificent conquests in the world of science and of the industrial employment of waste are recorded. To-day the manufacture of cement constitutes one of the twelve most important industries in the United States, and the greater part of this material is made from what a few years ago was accepted as sheer waste—residue from the iron-works which, having no further ostensible use, was dumped in huge piles to the disfigurement of the landscape. To-day this waste is being turned into building material, having usurped the product originally selected for this duty.

The reason why there should be such a deep-rooted antipathy to concrete for house-building purposes in these islands is somewhat inscrutable. Probably it is due to the experiments which were made many years ago, and which owing to our limited knowledge were construed by the quidnuncs into a failure. But because Brunel's *Great*

Eastern did not succeed we do not laugh at the mammoth steamship of to-day. Brunel's conception suffered merely from being premature. So were the first attempts to use concrete in the house-building industry. During the past few years we have acquired further knowledge which should enable us to steer clear of the blunders of the past, but instead of grappling with the problem along the lines which science is vividly blazing we prefer to waste time in the idle discussion of quaint theories and fantastic notions.

Many are the reasons why concrete should be employed. In the first place it is difficult to excel for simplicity. It comprises essentially two materials—cement, sand and rubble, the two last-named being generically described as the aggregate. The term is wide in its meaning, comprising virtually any and every inorganic material capable of being crushed to a pre-determined size, and the character of which may be as varied as the number of days in the year or more, while recent investigation has indicated that even the conventional sand may be eliminated, provided a sharp and gritty substitute in a similar powdered form be forthcoming.

Think what this means and the many possibilities it opens up! In the first place it enables material on site—waste—to be turned to economic account, and the term waste in this instance is extremely elastic. There is no need to disfigure the countryside with yawning craters in the form of pits for the excavation of the special clay suited to the making of bricks. Again we must not forget that by the employment of the conventional building materials a demand is made upon transport, which to-day is as acute as the scarcity of houses. With concrete the only constituent calling for transport from a producing point is cement, and this only involves the movement of one-seventh of the load which would otherwise be involved were bricks to be used. In other words, if seven tons of bricks were required to build a house it would only be requisite to move one ton of cement to yield a similar house in concrete—the other six tons of essential materials could be acquired on the site. The avoidance of superfluous expenditure as well as the economy in time and labour is obvious.

Our towns and cities are daily shedding tons of a specific form of waste—ashes and clinker from electric generating

stations, water-works, gas-works, and refuse destructors. The contribution naturally varies according to the population, but a small town burning 40 tons of refuse in its destructor may safely anticipate accumulating clinker at the rate of 8 to 10 tons a day. The disposal of this residue presents a problem in itself. A certain quantity can be absorbed in connection with the sewage beds, road-making and other incidental tasks, but, for the most part, it has to be dumped, merely because it possesses no ostensible application. When one reflects upon the activities of the factories in a manufacturing town and the daily output of clinker and ash from these sources alone, it will be seen that the civic clinker disposal problem is likely to assume enormous dimensions, and to prove a costly issue in itself. Thousands of tons are dispatched by road, rail and water from our towns and cities to be jettisoned at suitable points where unsightliness does not count. The authorities of New York City used to ship hundreds of tons daily 60 miles out to sea, while at Liverpool it had to be barged for 24 miles to be thrown overboard into the Irish Sea at a cost of 2s. 6d.—60 cents—a ton! Many borough authorities will readily give away the material to those who care to fetch it, so keen are they to be relieved of this incubus. Yet, in every instance, the equivalent of sovereigns are being shot upon the land, dumped into the sea, or given away as the case may be.

Cannot a more economic use for this and kindred refuse be found? This is the obvious question in this utilitarian age. Yet it is almost superfluous to launch the inquiry. It can be turned into concrete: could, and should, if we were sufficiently enterprising and astute, as well as frugal in our habits, be turned into houses. Certain attempts have been made towards the conversion of this residue into constructional material such as kerb-stones for lining our pavements, slabs to take the place of York flagstones and bricks for paving purposes, the building of sheds and other insignificant structures, but none represents a grim attempt to wrestle with the issue along bold and comprehensive lines.

Some years ago, the city engineer of Liverpool, Mr. John A. Brodie, M.Inst.C.E., one of our most enterprising city engineers, essayed a bigger step forward. He was faced

with the disposal of 50,000 tons of clinker from the city destructors during the year. He made a bold effort to turn it to economic account in the obvious directions—paving and kerbing operations—but these channels absorbed only a round 20,000 tons, leaving some 30,000 tons to be shipped to sea to be dumped at a total annual cost of nearly £4,000—$20,000. The city authorities had resolved to carry out a tenement building scheme, and the city engineer decided to provide them in concrete and to use the refuse from the destructors as the aggregate, exacting tests having convinced him of its suitability for this purpose.

The building, covering an area of 3,717 square feet, of which total 1,611 square feet are open space, is of three floors with four tenements on each floor, finished off with a flat roof, surrounded by a parapet for washing, drying, or playground purposes.

The construction of the building was carried out upon the section or slab system. That is to say the walls, floors ceilings, and other parts, with all necessary openings, were moulded at the destructor works, and set aside for a time to mature. Some of these slabs were of imposing dimensions, ranging up to 16 feet in length by 13 feet wide, 14 inches thick and weighing 11 tons. Upon arrival at the site they were slung into position and dovetailed into place, thus forming a rigid structure.

As an indication of how modern thought may be hampered severely by prevailing notions it may be stated that, as a result of his deductions and experiments, the engineer decided that a thickness of 7 inches for the walls would be adequate. But his decision was over-ruled. The existing regulations insisted that brick walls should be 14 inches thick and the concrete had to comply with these rules. The result of this indefensible policy, for which misconception and lack of knowledge were responsible, was to double the weight of the structure and to inflate the cost of the buildings to an unnecessary degree. The engineer computed that if construction were carried out upon the lines he advocated the building could be completed, including the provision of all necessary plant, for £1,230—$6,150. Enforced compliance with obsolete rules inflated the cost to £4,072—$20,360. In other words the ratepayers of Liverpool were compelled to spend £2,842—$14,210—more than they need

have done—a flagrant waste of money, material, time, labour, and knowledge.

One objection which has been levelled against the concrete house is the concrete floor. But to surmount this objection the Liverpool engineer embedded wooden scantlings in the concrete, covered the surface of the latter with a layer of pitch mixture applied hot, and then nailed down $\frac{3}{4}$-inch floor-boards in the usual manner. In this way the so-called defects of the concrete floor were completely overcome. The walls were subjected to several experiments to determine the most suitable internal finish, some being papered, others plastered, while in further instances a simple coating of sanitary wash or lime was applied. It was found, however, that for such buildings, distemper was the most efficient finishing medium.

This experiment conclusively substantiated the claims advanced by the engineer. It demonstrated the fact that concrete lends itself to rapid construction, the Liverpool building, despite its size, being erected and roofed within three months, notwithstanding frequent cessations owing to inclement weather, and was ready for occupation within another eleven weeks—say six months in all. It is safe to assume that had brick been employed it could never have been finished in the time.

The advantages of concrete for such domiciles are obvious. The structure is as near being fire-proof as it is possible to contrive. It complies with every requirement of hygiene. It is substantial, weather-proof, and sound-proof, while it improves with age. Concrete, unlike the common grade of brick, does not deteriorate under the influences of time and weather. The walls offer no refuge for vermin, unless papered, and should a room become infected as a result of contagious disease among the inmates, it can be promptly sterilized by turning on a hose of boiling disinfectant and being scoured from top to bottom. Rats and mice cannot secure a refuge, because the extreme hardness of concrete taxes their gnawing powers to the superlative degree.

The experience of Liverpool was adequate to drive home the fact that concrete dwellings are not only able to provide the poorer classes with a substantial home, complying in every respect with modern requirements, but also indicated a profitable use for an otherwise useless waste product. Were

comprehensive schemes carried out upon these lines the cost factor might be reduced to the absolute minimum by recourse to standardization in the preparation of the slabs. As a result of this initial experiment—the first of its character in Great Britain—the Liverpool city engineer estimated that he could erect future buildings of this type, in blocks of five, at £1,700—$8,500—each, and that this would show a saving of 25 per cent. over the cost which would be incurred if brick were used. But, and this was an important factor, to achieve this end it would be incumbent to allow the engineer to pursue his way unfettered by obsolete ideas, fallacious notions, and antiquated rules and regulations.

Some years ago Edison precipitated a mild wave of excitement by the perfection of a process for moulding houses complete in a solid block, much along the lines followed by the housewife in the preparation of jellies and other similar table dainties. He suggested the erection of a mould to the design of the desired house, including both internal and external artistic embellishments, and then to run the concrete into the metal shell in liquid form and to allow it to set and harden. Then the mould was to be demolished, leaving a solid monolithic-structure from foundation to roof, and without a crack or a joint. The mould, naturally, was built up in sections, which could be standardized and interchanged, so that once a set of moulds had been acquired a house of any desired dimensions might be erected. Of course, this demanded an imposing array of moulds, entailing heavy initial capital expenditure. Edison frankly admitted this to be the weak point in his scheme, because the mould bill for the construction of a "poured" house, as it was called, costing £240—$1,200—would be at least £5,000—$25,000. Consequently the suggestion was impracticable, unless the builder were given an imposing house-building scheme to complete, to enable him to distribute his mould charges in such a manner over the houses as to increase the actual building cost of each only by a trifling amount.

Edison's conception aroused extreme interest in America and provoked widespread ridicule in these islands. The "poured" house was regarded in the same light as was the telephone upon its first appearance in London. As the latter was declared to be merely a "scientific toy," so was the poured house described as nothing but a wild dream.

But, be it noted, antagonism and objection have been levelled from the fickle standpoint of theory; we have no practical experiment to guide us in our assault upon Edison's idea. Instead of setting to work to prove, or disprove, the practicability of the poured house we wasted time in academic discussions concerning "sweating walls," condensation, coldness in winter, and to embark upon high-falutin diatribes concerning the imperative necessity for such abstract demands as "breathing bricks," and other fantastic ideas which possibly are of interest but do not advance the realization of the cheap house, contribute to the solution of the housing question, or proffer a single step towards the utilization of waste.

The Americans are more enlightened. A new idea is subjected to practical test and discussed afterwards, not destructively, but in the hope of being able to solve the defects which have manifested themselves in the experiment with a view to establishing the commercial success of the idea. While our house-building quidnuncs are leaving no stone unturned to prevent poured houses becoming an established practice, our engineers are setting to work in the American fashion, and as a result we are building poured concrete ships and other articles of utilitarian value. Possibly they are not poured in the strict interpretation of the Edisonian term, but modified according to experience which has been gathered.

In 1909 the International Congress on Tuberculosis assembled at Washington D.C. To stimulate interest in a house built along such lines as to comply with the searching requirements of perfect sanitation and which would be particularly adapted for occupation by persons suffering from tuberculosis, a reward was offered for the best model of a germ-proof house. A young Washington architect-engineer attacked the problem, submitted his conception for such a house, of the "poured" type, and because it triumphed over all competitors, which clung to the rutted line of thought, in the provision of light, air, and sanitation features, carried off the prize.

In this design the cellar which, if damp, forms an ideal breeding-ground for germs and disease, was eliminated. Floors, walls, ceilings, cornices, bath—all were of cement poured into moulds. In each room the floor was given a

slightly sloping depression at one corner and provided with a suitable outlet and trap. The idea was obvious. The housewife on cleaning day did not raise impenetrable clouds of dust to pollute the room. She simply removed her furniture, together with all hangings, to be beaten in the open air. Then she turned on a hose and flushed floor, walls, and ceilings, the water escaping through the trap. No dust whatever was raised, and the room was left dry, sweet, and clean. There were many other features contributing to the general attractiveness of the scheme. The model aroused more interest than any other at the Congress exhibition, but, while one and all declared the house to possess every attractive feature, it was regarded as merely a fantastic conception.

But, within the past eight years, more than one little "poured cement" garden city has come into being in the United States. The first commercialization of the germ-proof house was made near Washington. It was run up and occupied within 30 days, and was conceded to be one of the prettiest and most comfortable homes in the countryside, although it cost only about £400—$2,000. To-day it is surrounded by many others.

The scheme has triumphed because the Washington architect-engineer, instead of deriding Edison and dwelling upon the defects of the idea, set out to overcome the problems involved, especially that identified with the moulds. He has succeeded. Instead of demanding an initial expenditure of £5,000—$25,000—upon this preliminary he has reduced the mould expense down to £100—$500. This brings the idea within the reach of commerce. He does not advocate a mould for the complete house, but pursues what may be described as sectional-stage moulding. Plates of steel are pressed into flanged sections 24 inches square. These are clipped and wedged together to form a trough to hold the liquid cement until it hardens. Above this row of plates is disposed a second similar row, forming another trough upon the top of that which has already been filled, and which is setting. When the lower trough contents have hardened the lower array of plates is rolled over to form another trough above the one in which the cement has been run, this overlapping process, as the wall hardens, being continued until the top has been reached. These plates

also serve as forms for the moulding of the floors and roof, and are additionally attractive because they readily admit of the introduction of any desired artistic finish. It is a system which lends itself to cheap and rapid construction, as events have amply proved. That the "poured" germ-proof house, built in one solid block, possesses distinct advantages over the building carried out along orthodox lines is evident from the alacrity with which such homes are purchased or occupied, a tendency which is just as pronounced in this country as in the United States. This tends to demonstrate that while the man-in-the-street knows nothing concerning the pros and cons of building materials, he certainly does appreciate the overwhelming advantages of concrete, which, be it noted, is the logical antidote to jerry-building.

That the poured, one-piece house is not merely attractive because of its relative cheapness is evidenced by the number of stately homes which have been built in accordance with this principle upon the other side of the Atlantic. Seeing that these homes have been built to the order of, and are occupied by, those to whom cost is a trifling consideration, it would certainly seem as if the so-called defects of the poured house were more imaginary than real. I have seen magnificent homes, ranging in cost from £5,000 to £25,000—$25,000 to $125,000—built from foundation to roof upon the Edisonian idea. They certainly would have been promptly demolished and rebuilt in other material if the monolithic house possessed even the slightest sign of any one of the many ills to which it is academically said to be exposed.

Industrial corporations in the United States, as in Britain, are faced with problems concerning the housing of their employees. And they are just as perplexing to solve. The Delaware, Lackawanna and Western Railroad Company was concerned with the provision of homes for its wage-earners in the vicinity of one of its mines. The question was surveyed from every possible angle, and finally it was decided that the only really attractive solution was the provision of a little garden city of concrete houses, built upon the poured system. The authorities concluded that in this way only would it be possible to provide model sanitary homes, possessing every inducement, at an attractive price, and the project was handed over to the architect-engineer whose germ-proof house had aroused the interest

of the International Tuberculosis Congress two years previously.

The houses are built in pairs, thus being semi-detached. Each is of two floors with flat roof, the accommodation comprising on the ground floor living- and dining-rooms measuring 11 feet and 11 feet 6 inches by 12 feet 4 inches, respectively, large kitchen, pantry, and commodious lobby with the projecting porch incidental to American homes. Upon the first floor are two bedrooms measuring 11 feet 3 inches and 11 feet 6 inches by 12 feet 6 inches, a smaller room, and a porch which may be used as an open-air sleeping chamber, if desired, or lounge, with the usual offices. The houses are set out after the manner now being followed in these islands, that is around the four sides of a rectangle, facing a commodious green and flanked on the opposite side by a deep green lawn. The roads skirt the village on all sides, the highway approaches to the inner square being diagonally from each of the four corners.

In carrying out the scheme the designer decided to utilize to the full the available materials upon the spot. This was waste from the adjacent mines, in the form of cinders, with hydrate of lime to give density and weather-proofness. Speed in construction being a vital factor, a novel system was introduced. A railway track was laid around the entire group of 40 houses. The mixing plant was mounted upon one flat car which was also equipped with an efficient apparatus to hoist the concrete. Behind this was a second car carrying the cement, sand, and cinder. The ingredients were shovelled into the mixer, work being continuous. The train pulled up before the first pair of houses, the moulds forming the trough of which were in position. The concrete was hoisted and discharged into an elevated hopper on the vehicle from which a feed pipe and spout was extended to the mould trough of the house-wall. The concrete was run into the trough until it was filled, when the stream was shut off, the feed pipe lifted, and the train moved on to the next house, where the cycle of operations was repeated. By the time the train had completed its circuit and had again reached the first house the concrete previously poured had hardened sufficiently to permit the moulds to be raised to form the succeeding trough, and so was ready to receive another pouring of cement. It will be seen that

construction throughout the 40 houses was not only continuous but each supply of concrete increased the height of the wall by about 24 inches, or completed the flooring as the case might be. The building process was not only exceedingly simple, being free from all complicated mechanism, but involved the employment of the minimum of labour, which conduced to extremely cheap erection. The re-setting of the moulds occasions in this system no difficulty, inasmuch as being hinged they are merely swung up and automatically fall into position to form the mould. The work was commenced late in the year 1911 and was completed in the spring of 1912, having to be suspended during the winter months, when, of course, all building operations, irrespective of materials used, is brought to a standstill.

The houses provided in this manner are not only attractive, but are provided at a price bringing them readily within the reach of the wage-earner. True, one objection might be levelled against such standardization as it were, and that is the stereotyped design, but in this instance this is possible of decided relief by resort to tree, shrub, and flower embellishment in which individuality is given free rein, and which effectively breaks up all tendency towards monotony. But apart from extraneous treatment, the village cannot be described as being more monotonous than our terrace system of providing homes for the workers so common to our industrial centres, while even our much-vaunted garden cities are freely criticized from the general atmosphere of similarity.

However, it is cost of construction which constitutes the all-important factor, and the poured house has demonstrated what can be done in this instance. A similar cement city is under way for residential purposes upon the outskirts of Chicago. The bungalow type of house is being favoured here. In this instance cellar walls and first-story walls, measuring some 30 by 40 feet, have been poured in four days. The cost of construction has been exceptionally low, even for America where higher wages and charges prevail, the cost of building a 6-inch wall which in poured concrete is ample for either one- or two-story buildings, having been brought down to 4d.—8 cents—per foot, which is well below the cost of frame houses, admittedly the cheapest form of construction in the United States.

The poured house or any other system of monolithic

structure wrought in concrete is freely assailed in these islands for being damp, intolerably cold in winter, hot in summer, and the walls liable to condensation. These are the popular objections raised against the idea. But the experience of those who live in such homes in America completely refutes such statements. The houses are declared emphatically to be bone-dry, exceptionally warm in winter with a freedom from draughts, cool in summer, and free from condensation. The latter defect, it is pointed out, even if it should become manifest, is not irremediable. The chemist can solve it quickly and cheaply. But the great feature which makes irresistible appeal to those who dwell in such homes is that they are always sweet and clean. Washing down walls, ceilings and floors of a room at one and the same time with a garden hose is something beyond the comprehension of British householders, but they will scarcely deny its virtues, and, probably, wish heartily that they were in a similar happy position, because nothing detracts so seriously from the pleasures and comfort of the home as dust and dinginess.

While we display an inexplicable hesitation to build a single house upon the poured system to discover the character of the objections which are said to obtain, thereby ignoring the precept that an ounce of solid fact is worth a ton of theory, we are steadily moving towards the concrete home, although the pioneers are being called upon to battle fiercely against the organized forces of prejudice, conservatism, and vested interests. In order to comply with national and other traditions, so far as practicable, the brick system is being followed. Machines have been devised whereby bricks, but wrought in concrete, are speedily and cheaply produced.

The outstanding characteristic of the most approved of these appliances is the ability to fashion brick-like masses of concrete of varying sizes and dimensions. One of the most handy machines of this character is the "Winget," wherewith a wide variety of concrete formations may be fashioned cheaply and expeditiously, and adapted to every conceivable building requirement. This machine is noteworthy from the simplicity of its design and operation, compactness, and high speed of working, as well as imposing the minimum demand upon skilled labour. The concrete is not run, but is shovelled into the mould and tamped down.

When charged the depression of a lever lifts the block, and in such a manner as to permit its ready removal by two men armed with a carrying bar fitted with forks which grip the under edges of the mass.

This machine has been extensively utilized in this country, and it has proved highly efficient in working. It is excellently adapted for the preparation of blocks or slabs from waste materials, such as the clinker refuse from electric light generating stations, dust-destructors, and other industrial establishments in general, as well as such other residues as coke breeze, chalk, and rubble. High speed of working, combined with the size of the block which may be turned out therewith, enables it to consume such material at relatively high speed. In a Midland town where aggregate of a waste character was required for the fashioning of such blocks, the whole of the daily accumulation of residue from the local electric light station, averaging seven tons, had to be supplemented by supplies of similar waste from private industrial establishments to keep the machine working steadily throughout the day.

With such a machine practically any form of inorganic residue can be put to useful constructional account. Its perfection is enabling private authorities to exploit profitably dumps of refuse which have long been eyesores in the locality for material to satisfy their own building needs. One gas company, which formerly contracted in the usual way for extensions to its buildings, generally in brick or stone, now completes all such work with its own labour and with its own waste, its one expenditure for material being the requisite cement. It encountered pronounced difficulty in disposing of the coke breeze or dust; it was virtually unmarketable. Conspicuous piles accumulated because it was disdained as fuel. The company acquired a "Winget" machine, and by mixing the breeze with cement converted the useless refuse into substantial building blocks. Those which it does not require for its own building operations find a ready market. The outstanding fact, however, is that all recent building extensions are carried out with concrete blocks prepared upon the spot from material which the company produces during the conduct of its business and which has always been considered waste having no commercial value whatever.

To the municipality, faced with residue accumulating from the refuse destructor, gas, and electric lighting installations, such a machine is virtually indispensable. It offers a complete economic solution to a perplexing problem. A certain amount of official building is always necessary, and concrete blocks with clinker forming the aggregate constitutes an ideal and inexpensive material. One great objection often raised against the utilization of cinder and other similar residue for this purpose is the dingy tone of the resultant block. But this need not constitute a handicap. If used for the external walls of cottages the concrete can be finished off in rough-cast, or may even be plastered and painted. In many instances excellent reproductions of half-timbered styles have been carried out in this material, and are far more substantial than those wrought in the conventional brick.

But the chemist must be harnessed to the development, that is if the most satisfactory results are to be obtained. It is the tendency to ignore the chemist which has been responsible for much concrete failure for homes in the past. It is imperative that clinker refuse be analysed. If it be associated with fused glass it is useless for the purpose, for the simple reason that the smooth surface of the glass fails to afford the requisite gripping surface to the cement. Unless care be displayed in this connection disintegration of the block will set in, in which event the concrete will be condemned as a failure when, as a matter of fact, it is the ignorance of the individual and the presence of the glass which are responsible for collapse. Similarly it is essential that the aggregate should be free from organic material. This may be intensely dry when the mixing of the concrete is taken in hand. But the organic material will absorb the moisture after the manner of a sponge, continuing to do so until completely saturated. As a result of this action the material necessarily expands, and so will bring about the breakdown of the concrete. Therefore, if full advantage be taken of the chemist specializing in constructional material in the scientific preparation of concrete, as is done in Germany and the United States, failures will be few and far between.

The authorities of our towns and cities are called upon to handle 5,300,000 tons of dust and rubble collected in the dust-bins of the population during the year. In addition

millions of tons of similar refuse accumulate from the consumption of coal and coke by the thousands of industrial establishments scattered over the country. How much of this huge yield of waste is turned to industrial account? But an insignificant fraction, as is proved by its commanding no market value. Certain enterprising authorities, such as the City Fathers of Glasgow, by taking a little trouble, are able to dispose of the whole of their output of this residue and at a profitable figure. Surely what can be done by one authority is capable of being achieved by others up and down the country.

But clinker waste is not the only refuse adapted to building operations. Concrete is something like paper—can be made virtually from anything. There are few building sites which are not capable of yielding something in this respect. This was demonstrated very conclusively in the course of the development of an estate in Ireland. The work was most comprehensive, involving the provision of factories, workshops, farm buildings, and private residences. To prepare the site it was necessary to remove a substantial hill. Instead of excavating the obstacle, dumping and levelling the soil in the usual manner, it was turned into a "Winget" machine to be converted into concrete blocks, which were then utilized as the wherewithal for the construction of the buildings. The result was conspicuously successful, and it is doubtful whether the development scheme could have been carried out so economically and inexpensively in any other way.

There are welcome signs of revived interest in the possibilities of concrete for the building of our homes. In many parts of the country there are enormous hillocks which at the moment are nothing but eyesores. The pottery district may be cited as a case in point. These disfiguring piles have hitherto been ignored, although the localities are clamouring wildly for increased housing accommodation to satisfy the demands of their citizens. Yet these heaps are really potential mines of wealth. Associated with cement and deftly fashioned they can be converted into concrete bricks, the waste constituting ideal material for the aggregate, while, should we be sufficiently enterprising to acknowledge the possibilities of the poured cement house, their value is equally established. No city, town, or village in these

islands should suffer from a shortage of houses for its peoples, and none need tarry for bricks. They have ample constructional material at their very doors to build as many houses as they can possibly desire. To turn these potential resources to account it is only necessary to abandon our moth-eaten shibboleths, revise our laws and regulations governing building operations, forget a good deal of what we are supposed to have learned in the past, and turn to science and engineering with a more enlightened spirit. By combining the artist with the engineer and the chemist, and by admitting the utilitarian possibilities of waste, all the difficulties assailing this country at the present moment in regard to one of its greatest sociological problems might be overcome, and the inhabitants of the British Isles provided with drier, more comfortable, and more durable and artistic homes than have ever been brought within their reach during the centuries which have passed, and at a fraction of the cost which is now held to be inevitable if brick is to be employed.

CHAPTER XX

THE FUTURE OF THE WASTE PROBLEM: POSSIBILITIES FOR FURTHER DEVELOPMENT

WHAT is to be the future of the Waste Problem? This is the question agitating all circles to-day. The observance and practice of economic methods are being forced upon us owing to the high prices which are obtaining for every description of raw material, whether intended for the table or the factory.

To a certain degree the action is automatic, from the simple circumstance that supplies are strictly limited. Money does not constitute such a determining factor to-day as was the case five years ago, although of course it still exercises a far-reaching influence. But the mere fact that an adequacy of raw materials cannot be procured merely because one may be disposed to pay fictitious prices, is stimulating interest in the waste issue to a degree which, under conventional conditions, would never have obtained. In times of plenty one does not pause to consider for a moment as to whether it is worth while to devote any time and energy to the exploitation of a certain refuse.

But the great question is one not so much concerning what we can derive from wastes, but whether we have really digested the lessons which the enemy has taught us. On every side we see startling evidences of what he was able to do by scientifically turning over and using the rubbish-heap, and the great wealth he was able to acquire by following such practices. We found ourselves hit at every turn and, in the hope of solving the critical situations which arose, were forced to follow the enemy's example and become a nation of *chiffonniers*. We have acquired wealth in the process, have discovered the value of the mine which the

junk pile represents, and realize that more wealth still remains to be extracted from such untapped resources.

We have also become intimately conversant with what may be described as the most perplexing phases of the problem, the greatest of which is the segregation and collection of the residues. It is upon this rock that all future effort regarding the scientific exploitation of waste, in these islands at all events, is in danger of being wrecked.

The mere description of what we ourselves cannot use in the course of our operations, as waste, or rubbish, invests the project with a dangerously false atmosphere. Being regarded as worthless there is a tendency towards the opinion that its collection and segregation should be conducted along honorary lines. This is a precarious policy, because it repudiates the fundamental law of the labourer being worthy of his hire, whether it be in ploughing, the smelting of steel, shipbuilding, or the collection of waste.

Simultaneously another immutable law is being flouted. All matter, irrespective of its character, which is capable of being considered as a raw material, must command a market value. It may be high, or it may be low, but the fact remains unchallenged that it possesses a certain intrinsic worth. Refuse, which can be worked into something useful, is just as much raw material as a shipload of ore, or a consignment of gold. It is its mere classification as waste which imperils its commercial significance. This is demonstrated by the sudden importance and value it instantly commands when it becomes labelled, not "waste," but a by-product.

In these circumstances, therefore, it would represent a decided progressive step if a recognized market could be established in waste products. By so doing all residues could be given accepted commercial values with which one and all might become acquainted by perusing quotations, in precisely the same way as the movement in the prices of raw materials may be followed by reference to the daily or weekly market lists. Until such time as wastes become so recognized the uncertainty of supply must obtain, because it is the very ignorance of the subject which contributes to the loss of such material through fire and other equally destructive measures with its appalling loss of wealth.

The establishment of a market price for all and every

description of waste would act as the direct incentive to preserve anything and everything for further possible use. This was proved very conclusively during the war, when bones and paper were in such urgent request, the one for the reclamation of the fat, and the other for re-pulping. Under normal conditions both wastes had received indifferent consideration, and immense quantities of the two materials suffered complete useless destruction by fire. The premium placed upon the price of bones was only ½d., or 1 cent, a pound, the butcher being regarded as the collecting medium. That is to say the bones would be paid for at the above rate upon surrender to the butcher. The reward was not high, but it proved to be sufficient to induce people to husband their bones and to dispose of them in the recognized market. It was the same with paper. The average housewife devoted but little attention to the harvesting of this waste until she learned that the authorities were ready to pay 1d.—2 cents—at least per pound therefor through its accredited agents. Instantly she commenced to display thrift, and was somewhat surprised by the money which could be picked up in this manner. Yet it is safe to assert that had no financial value been placed upon these wastes barely 50 per cent. of what was actually secured would have been forthcoming.

Unfortunately there is a large class of waste exploiters which is disposed to trade upon the ignorance or indifference of the community. In the knowledge that the average house, office and factory has no conception of the value of its refuse, or is ready to part with it for nothing because it is regarded as a nuisance, the waste merchant is disposed to become discriminatory and autocratic. He is perfectly ready to acquire what he knows full well possesses a distinct value so long as he can get it for nothing. The moment the owner sets a value upon the flotsam and jetsam the waste merchant will have nothing to do with it. He assumes an indifferent if not a dictatorial and impossible attitude to which the second party to the projected bargain takes immediate exception. The upshot is that sooner than part with the material for nothing, and in the knowledge that the acquirer is certain to sell out in turn at a profit, the material is withdrawn completely from possible circulation, and so suffers irretrievable loss. To barter is human, and

this applies as forcibly to waste as to houses, commodities and produce in general.

The waste market must be set upon a firm and solid basis. Those who have specialized in this field of trading during the past few years, and, as a result, have become acquainted with its possibilities, and the true value of such material as is to be obtained through the devious channels, are in the position to effect such a reform. The price of waste is naturally subsidary to the fluctuations in the market quotations of the materials whence it is drawn, as well as of those normally employed in the industries to which waste may be applied. The general conditions are decidedly more complex than those prevailing in the handling of straight materials, for the simple reason that then only the one market needs to be watched.

Factors of cost also require to be closely followed. In the true economic and scientific exploitation of all waste products the question of cost is vital. It may easily jeopardize such utilization. Naturally a margin of profit must be available from the working-up of the material, not only to ensure its use, but also to safeguard the sources of supply. This margin must be determined, not on the top of the market as is the case at the present moment when conditions are abnormal, but when prices for raw materials are at their minimum. If, then, the exploitation of waste can be conducted in such a way as to compete successfully with ostensible raw materials, recovery must hold its own to become more and more profitable as the market rises. By-products can be exploited only so long as the cost of preparing them for commerce proves profitable. If it should become cheaper to treat raw materials for a similar article then waste reclamation must suffer abandonment, except in those rare instances where every contributory source of supply must be pressed into service. Such conditions rarely obtain on a low market, because the latter is directly attributable to the circumstance that supply is in advance of demand. It is the inversion of this law which forces high prices.

Efforts have been made to stimulate the preservation and surrender of waste along voluntary lines. But such measures cannot hope to be commercially successful, except under peculiar circumstances, as for instance when patriotism may act as the incentive. The voluntary handling

of waste must of necessity prove wanting because it is deficient in discipline, method, and organization such as science demands to fulfil the conquests she indicates. Compulsory measures are absolutely imperative, otherwise all the mickle which makes the muckle must slip through the meshes of the net, no matter how well it may be cast. The Germans were enabled to bid defiance to the world, notwithstanding the stringency of the blockade, by the elaboration of rigid laws ensuring the collection of all waste. Such measures were in force more or less during the halcyon pre-war days, but were severely tightened up when national existence was seriously threatened. Similar compulsory methods will need to be introduced into this country to ensure the full recovery of valuable materials for industry, that is if we are to reduce our purchases from abroad. The desired end can be achieved indirectly by prohibiting the acquisition of the obvious raw materials from foreign sources, because instantly the refuse and residues capable of taking the place of the raw materials will commence to appreciate in value and accordingly will be preserved and utilized.

But the citizens of Britain are opposed to compulsion in any and every form. To impose such conditions is to interfere with the liberty of the subject, although absolute and unfettered freedom, as experience has adequately testified, reacts against the welfare of the individual and the community in general. Failing uncompromising compulsory measures is it possible to achieve comparative success by spontaneous private enterprise?

To obtain an indication of what can be achieved in this direction it is necessary to go to the French capital. There an enterprising and energetic Frenchman, Monsieur Verdier-Dufour, undoubtedly built up one of the largest businesses in the world—founded upon dust-bin waste. The organization was somewhat intricate and full of inner workings although highly effective in the production of results, because the guiding spirit knew that everything has its specific use.

The operation commences in the gutter at the bin in which the householder has dumped his refuse and which he has moved to the kerbstone for collection. Now the Frenchman is a cute bargainer, as the whole world knows, and the concierge, after the passing of the ordinance com-

pelling the householder to bin his refuse, promptly saw a means to improve his pocket. The bin was a lucky dip and accordingly was well worth exploiting as a concession. He promptly drove a bargain with one class of the vast army of Paris waste-gatherers which entitled the individual to rummage the bin before the collector came along, the only requirement being that the "miner" should be up early and on the spot before the refuse carts commenced operations. The *placier*, as this individual is called, did his work well—the bin contained little of material value after he had sorted its contents. But other less luckless members of the garbage-rummaging fraternity did not spurn to submit the tailings from the first process to another treatment and reap a harvest in the process.

The odds and ends gathered in this manner, and which were of a most diversified nature, for the most part found their way to Monsieur Verdier-Dufour's establishment, where the precise value of each article, and the grade of each range of substances, became known to the uttermost centime. Nothing was too small to be examined and each article had its individual bin. The man at the helm knew the exact application for each article, while he was a master-mind in following the markets. When quotations were abnormally low he could hold on for the return of better times. His waste commanded the admiration of the firms with which he dealt because he maintained the standard of his products which were exactly as described. Manufacturers merely had to dump the waste into their machines, thus treating it as if it were raw material. There was no interference with the rigid routine of their business, nor were they called upon to expend a further penny in rendering the waste suitable for their intentions. So the master-mind built up a large and highly lucrative business and thus there was very little household waste which escaped reclamation.

Co-operative societies among the rag-pickers supplemented individual effort in this field. In this instance the process is simpler because it is conducted along broader lines. Sorting is not conducted to such a fine degree as under the individual system above described. Consequently it suffers because lower prices are paid. Waste commands a price according to the time and labour which will have to be expended by the purchaser before such material can be

safely turned into the precise channels of the huge manufacturing machine for which it has been acquired.

The objection to both co-operative and individual methods, such as I have described, is that they can only be conducted upon the requisite scale in the very largest cities where the volume of material to be handled is relatively heavy. Waste must be forthcoming in a steady stream of uniform volume to justify its exploitation, and the fashioning and maintenance of these streams is the supreme difficulty.

Ostensibly, in this country we have the very finest machinery in existence for the reclamation of waste of every description—the municipal and civic authorities. But, as results have conclusively demonstrated, they are the least efficient institutions in this respect. The few cities which are able to point to great achievements in this field are the very exceptions which serve to prove the rule. They do so in the most convincing manner, and incidentally bring home to us very vividly the enormous wealth which we are deliberately throwing away through lack of enterprise and adequate organization.

The system is responsible for this deplorable state of affairs. The average municipal engineer, even if anxious to excel in this province, finds himself hampered at every turn. He is not vested with sufficient authority or freedom to carry any carefully prepared scheme into operation without the sanction of this, or that, Committee which, as a rule, is notorious for its lack of practical knowledge, more particularly in all matters pertaining to the value of waste. Then the multiplicity of officials and their salaries reacts against every possibility of a scheme being turned into a financial success.

It is a matter for serious discussion as to whether our whole system of waste recovery, in so far as it affects municipalities, should not be overhauled from top to bottom—even superseded. It should be entrusted to private enterprise acting under licence. Were such a force encouraged we might safely anticipate the provision of well-equipped comprehensive plants, similar to those which I have described, for the treatment of waste of every description incurred within the district in which it operates. To this centre should be borne refuse of every description for segregation and preparation for the mills of industry. Private enter-

prise, from its close contact with the markets, would be able to set prices at which it would be prepared to purchase waste of every description from a dog-mauled bone to a worn-out scrubbing-brush; a discarded daily paper to an abandoned straw hat or pair of tattered boots.

By fixing prices for all and every description of residue preservation and segregation at the source would be encouraged. The housewife, caretaker of the office, and manager of the factory would see that all waste was carefully husbanded, and that nothing possessing the slightest value would be thrown away. The dust-collectors could be encouraged to participate in the general round-up of waste by being given a commission upon all useful material brought in. It might be an over-riding commission to ensure complete and frequent collection. It is only necessary to apply sufficient stimulus in the form of hard cash to ensure that nothing is wasted. Private enterprise could carry out such a scheme whereas municipal authorities are precluded from following such a course.

Under private auspices it would also become possible to exploit the waste accruing in our rural districts. Residences by the wayside, hamlets and country homes from their isolation have escaped the tentacles of previous recovery systems. No recognized specialist in residues, with the exception perhaps of the wardrobe dealer, ever passes their way to pay a call. But, with modern motor transport facilities it would be possible to call at these possible scattered sources of supply for anything and everything, and at regular intervals, so that the owners might be induced to preserve their useful materials. It is maintained that such collection would never prove profitable. Possibly not when considered upon its own footing, but when contemplated in a general scheme it would not only be lucrative, but contribute to the higher efficiency of the plant employed from being able to raise the working output to one more closely approaching the maximum capacity.

Such a method of recovering the waste would stimulate competition which, in turn, would tend to the hardening of prices to the advantage of those who have waste for disposal. The plant would only need to study local conditions in so far as the disposal of readily decomposing refuse was concerned, such as that from householders, fish, meat and other

organic matter. The municipal authorities, by virtue of their powers, would be able to ensure that this class of refuse was collected and treated promptly in the interests of the health of the community. Such waste as is not susceptible to deterioration could be sent or drawn from distant points, according to the advantage of price offered, as is actually the case to-day in regard to certain materials.

Private enterprise would also exercise another far-reaching beneficial influence. It would not lag behind the clock of progress. Science is ever advancing and the exploitation of waste lies in its true scientific utilization. Under the present conditions inventive effort in this province is not able to exercise the influence or reap the benefits which it really deserves. The tendency to be satisfied with what is already installed, no matter how inefficient it may be, is too deeply implanted. On the other hand, competition is the lever which impels private enterprise. To turn a blind eye to invention is to court disaster.

Although we have made vast strides during the past few years in the processes of reclamation and utilization of waste we are still far from having penetrated the threshold of the new world of industry, science, and invention which it embraces. The unknown lies before us. For aught contemporary knowledge can say, other triumphs and vast fields of conquest, comparable with those associated with the gas and oil industries, are waiting to be discovered, and this fact is adequate to foster experiment, research, and investigation.

We talk glibly of exploiting waste, but how many products entering intimately into our everyday life are being passed through the mill of reclamation? A little reflection will speedily exhaust the list. If we look around we can satisfy ourselves how much and what a variety of substances are still being permitted to run to utter loss. We have not yet found a use for spent matches, or a means of retipping those which have been scarcely lighted, despite the fact that this indispensable attribute to modern civilization has increased from 300 to 800 per cent. in price. How many typewriter ribbons are used by the tens of thousands of offices in the country during the year, and what is done with them when withdrawn from the machines as being unfit for further service? What is done with the stones and

kernels from the millions of pounds of stone-fruits consumed during the year? The inventor is still confronted with the prize which will result from the discovery of an economic use for the 370,000,000 lb. of spent tea-leaves and 100,000,000 lb. of coffee-grounds left in our pots, cups, and urns during the twelve months.

The lists of wastes awaiting profitable disposal are extremely lengthy. Some appear to be as impossible of successful solution as the discovery of the non-refillable bottle. But effort is not confined to the perfection of processes for the treatment of untouched wastes, because the real solution of this problem lies in the full scientific utilization of the product reclaimed. The fact that a waste is being exploited does not imply that such utilization is the most profitable. Investigation may indicate another and totally different, as well as more lucrative application for a certain material. So the inventor is not confined to a narrow field; his opportunities are illimitable.

There is one outstanding factor governing waste reclamation which often escapes observation. It is the only means whereby the cost of living may be reduced. Obviously, if a specific substance, whether it be a foodstuff or raw material for manufacture, be applied exclusively to one individual purpose, and without the residues resulting from its preparation, a certain quantity of which must necessarily be incurred, being turned to any economic account, the one application must bear the whole of the cost involved. It is by turning the residues to some profitable account that the cost of the primary product can be reduced to an attractive level, and the wider the margin of profit on the by-products and the more numerous the latter, the greater the reduction possible upon the quotation for the staple.

For instance, were coal still to be distilled exclusively for its gas, the price of the latter to-day would be so high as to be prohibitive to all but the wealthy. It is the ability to exploit from two to three hundred, or more, by-products arising in the distillation process, which enables the gas itself to be sold at a figure bringing it within the reach of all. What would be the cost of our clothes were it not possible for the mills to take the discarded woollen garments, shred them, combine the reconstructed fleece with new wool, and thus produce a new cloth? It is shoddy, or mungo,

which has solved the problem of good clothing at a relatively low price for all, because, to-day, there are very few of us who could afford to buy suits made of 100 per cent. new wool.

There are few spheres of activity offering such attractions, or holding out such tremendous prizes to the persevering and brilliant of thought as that identified with the exploitation of wastes. The field is so vast as to be open to the endeavours of the layman as much as to the master of knowledge. While many of the questions to be answered are of severe technical significance, there are many which are equally capable of solution by the man, or woman, who has had no technical training. There are many " crown cork " problems awaiting solution, while there is equal scope and opportunity for those possessed of the powers of organization.

The opinion prevails in certain quarters that the present wave of interest in the scientific reclamation of waste is merely ephemeral. Doubtless this feeling prevails because of the extreme length to which the fetish of cheapness and extravagance had carried us and which shortcomings appeared to be so firmly ingrained as to form part of the British character. To a certain degree prevailing high prices are certain to persuade us to pay closer regard to this issue than has heretofore been the case. Nevertheless, the longer such abnormal conditions obtain the more impressed shall we become of the wealth to be won from waste. They will compel us to strive to extract the utmost from the raw material placed in our hands. They will induce us to become more and more reluctant to discard a material after we have secured all apparent worth which it appears to be capable of yielding, from the fear that the ultimate residue may still contain something of potential value which we have not succeeded in discovering.

While, doubtless, the gradual relapse of conditions to the normal will exercise the effect of causing us to pay decreasing regard to the value of the wastes, it is to be hoped that, by the time such a stage has been reached, we shall have become so powerfully impressed with the potentialities of residues as to continue to exploit them instinctively. If such be the case we shall find ourselves in the position of being better armed for the coming commercial struggle with Germany, to whom waste has brought extraordinary wealth

in the past. Thus equipped we should be able to meet a remorseless and clever commercial antagonist on more than level terms.

Of one thing we may rest assured. Germany, past-master in the art of exploiting wastes, will exert herself far more strenuously in this field in the future than she has ever done before. Economic considerations will compel her to keep her foreign purchases of raw materials down to the irreducible minimum and to force her sales abroad to the absolute maximum in order to secure the rehabilitation of her trade balance. To consummate this end she will leave no stone unturned to exploit her refuse of every description to the full. No one knows more than Germany what can be done with the so-called rubbish-heap, and no other country is more cognizant of the fact that the industrial exploitation of waste creates wealth. So it behoves us to keep a tight hand upon our residues from household, office, and factory, and to exploit them ourselves to our own financial and economic advantage.

THE END

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